GOVERNMENT OF INDIA

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

सत्यमेव जयते

Proceedings of the Seventh Meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India

HELD AT

Madras from the 7th to the 10th April, 1948

Published by the Manager of Publications, Delhi.
India by the Manager, Government of India Press, Simla.
1950.
Price : Rs. 11/2/- *or* 17*s.* 6*d.*

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INTRODUCTORY.

The seventh meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India was held at Madras from the 7th to the 10th April, 1948 in Rajaji Ha[ll]. The inaugural session of the Wing on the 7th April was opened by the Hon'ble Sri O. P. Ramaswami Reddiar, Premier, Madras after a welcome speech by Sardar Bahadur Sir Datar Singh, V.C., I.C.A.R. After the inaugural session, the Wing split into seven sub-committees to consider in detail the seven subjects on the agenda of the Wing. The meetings of the Committees were held on the 7th and the morning of 8th April. In the afternoon on 8th April, an excursion was arranged to Poondi, Reservoir and Research Station in which a good number of members joined. The plenary session of the Full Wing began on the 9th April and finished its deliberations on the evening of the 10th.

In inviting the Hon'ble Sri O. P. Ramaswami Reddiar, Premier, Madras to open the proceedings of the seventh meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India, Sir Datar Singh, the Chairman of the Board said :

Hon'ble Shri Ramaswami Reddiar and Gentlemen,

As Chairman it is a great pleasure for me to welcome you all to this seventh meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India. According to the existing convention, the meetings of this Wing of the Board are held in alternate years at the headquarters of the Government of India and at the headquarters of a province or an Indian State. We met at Delhi on the last occasion and we are meeting here this year. We are deeply beholden to the Government of Madras for having extended an invitation to us for holding this meeting here and for the excellent arrangements they have made for our stay and comfort. We are deeply grateful to you, Sir, for having consented to inaugurate this meeting in spite of your multifarious duties and responsibilities. One of my predecessors in office described this Board as a sort of agricultural Parliament in India. I am, indeed, glad to have this opportunity of meeting the members of this August body assembled here this morning from all parts of the country. I extend a warm welcome to the visitors and all other persons, and hope that they will take part in the discussions of this meeting. For a number of members, this will be their first meeting. I hope that the opportunity which this meeting offers of contacting representatives of various parts of India will prove useful and stimulating to them. I will particularly welcome Dr. Taylor of the American Embassy. Dr. Taylor has not been long in this country, but he has been taking a keen interest in the development of agriculture in India.

Gentlemen, you are all aware that we are meeting under the shadow of a great national calamity that has befallen India. India has been orphaned by the cruel hand of death which took away from us Mahatma Gandhi, our great and beloved leader, nay of the whole World. It is known to you all that his interest was not in politics alone but he was equally vitally interested in the well-being of the rural population of India. He had striven throughout his life for their uplift in diverse directions. The light that was illuminating the country has gone out but his memory will always be cherished by countless generations to come and his example will prove to be the beacon light in the path of the country's progress, whether it may be in the political field or in the field of social and rural development. Our heart is laden with grief, but we have to do our duty as he taught us. Before I proceed any further, I hope the house will agree with me to pay respect to his hallowed memory by passing the following resolution :—

> "The seventh meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India records its sense of deep grief and sorrow at the death of Mahatma Gandhi, the father of the Nation, the appostle of peace and amity and the source of strength to the rural millions of the country.

The meeting resolves also that a copy of the resolution be forwarded to Sri Devdas Gandhi and Sri Payarelal. I suggest that the resolution be passed by all of us standing and observing one minute's silence.

Gentlemen, let us now resume our task. Those of you who had attended the last meeting of the Crops and Soils Wing will remember that the Government of India had invited Dr. Shubart, a member of the United States of America Soil Conservation Service, to advise the Government on soil-erosion and conservation. Then we had also with us Dr. A. B. Stewart of the Macaulay Institute of Soil Research, Aberdeen, to advise Government on the conduct of field experimentation dealing with the problems of soil fertility and crop production with particular reference to manure. Both these experts toured the country extensively and discussed problems with Central, Provincial and local officers engaged in agricultural investigation. They have submitted valuable reports on their observations and these reports are at the present moment under the consideration of the Government of India. In so far as soil-utilization and soil-conservation are concerned, there is a proposal to constitute a permanent organisation to tackle these problems on a coordinated basis and decision is expected shortly. The recommendations contained in the reports of these experts have already been brought to the notice of the provinces and constituent states. The idea is that these important problems should be tackled from an all India aspect, and if the organisation referred to above is set up, it will be possible to ensure this. A review of the work done on the maintenance of soil-fertility in India and suggestions for future lines of work with particular reference to the effect of soil-fertility on the quality of crop production has been included in the agenda of this meeting I trust this will receive due consideration at the hands of the members and the Board will make suitable recommendations on the subject.

Since we met on the last occasion, important changes have taken place in the political set-up of the country and these have created certain special agricultural problems of vital importance. Consideration of these problems must receive the highest priority both from the Board of Agriculture in India and the Governments of Provinces and States. By the political division of India into Pakistan and the Indian Dominion, the principal jute growing areas of Bengal and the long and medium staple cotton tracts of the Punjab and Sind have been constituted into Pakistan. The result of these changes has been that India is faced with a serious shortage of jute, long and medium staple cotton and food grains like wheat and paddy. The Central Commodity Committees concerned with jute, cotton and other commodities have already taken up the question of stepping up the production in order to meet the deficiencies. Several subjects which go to form the agenda of our meeting have an important bearing on the problems that have arisen from the partition of the country. I will earnestly invite you to take part in the discussion of these subjects and contribute your valuable suggestions for solving the difficulties now facing India.

From the Agenda of this meeting of the Board, you will note that attention is proposed to be given not only to agricultural research and investigation but also to the important subjects of rural development and food

production. Measures for the increase of fodder production in the country are also down for consideration. I will specially invite your attention to subjects like the need for breeding crop varieties adapted to varying levels of soil fertility, cereal rusts and their control, and the fixation of short range and long range targets to maximise the production of food so as to make self-sufficient.

Gentlemen, you are already aware that in the recent past there has been an unprecedented drive for production of more and better food in the country but in spite of all that has been done, we have hardly touched the fringe of this vast problem. We have had to import food grains of the value of over one hundred crores of rupees annually during the past few years. Not only that, but in order to sell the imported food grains at the rates prevailing in the country, the State has had to suffer a considerable loss every year. This state of affairs cannot be viewed any longer with equanimity by any lover of the country and I am sure that in your deliberations this vital fact will always be present before you.

Another subject that should attract serious consideration is the review of the comparative merits of different methods of improved farming practised in the country. During the recent past, a certain amount of discussion has taken place on cooperative farming, mixed farming, collective farming, consolidated farming and the like. However it is felt that the Board should afford an opportunity of a comprehensive discussion on this important subject and make practicable recommendations which may conveniently be adopted by the various Provincial and State Governments to improve the yield of crops, bring more area under cultivation and to improve the economic condition of the cultivators. It is no doubt imperative that we must do our best to increase our production, and at the same time to preserve what we produce.

Gentlemen, I would not detain you any longer from your important work. Before I close my remarks I would ask you to remember that you are the custodians of the future well-being of the rural masses and I hope that keeping this fact before you, you will come to decisions which will have a far reaching effect on the economic condition of rural population. I have now great pleasure in requesting you, Sir, to inaugurate the session. In doing so, I once more thank you and your colleagues on behalf of myself and the members of the Board as well as of the Government of India for the excellent hospitality that you have extended to all of us."

In opening the proceedings the Hon'ble Shri O. P. Ramaswami Reddiar, Premier, Madras said :—

" Gentlemen,

I thank the President of the Indian Council of Agricultural Research for honouring me by asking me to inaugurate this Conference. On behalf of the Government of Madras I extend to the Indian Council of Agricultural Research a warm welcome to our Province. I hope the members would enjoy hospitality and be able to contribute much that would be of practical importance to the improvement of Agriculture in this Province and outside.

You all know that our country though predominantly an agricultural country is very much behind the other countries of the world in the matter of agricultural production. It is far behind the western countries in agricultural research and advance and still more backward compared to countries like China and Japan. The soil is the most important factor in agriculture. It is the gift of God to humanity. All that man can do is to see that the God-given soil is not depleted by erosion, exhaustion and other causes. It has been calculated that Nature is responsible for the provision of 95 per cent. of the requirements of plant life and all that men can do is limited to 5 per cent., and even in this limited sphere all that he does is to see that the humus is not lost and the soil is not carried away by erosion and apply of manure. Plants need 13 elements like nitrogen, potassium, calcium, manganese, iron, etc. There must be intense soil survey all over the country. The survey must be not only on the top soil but also of the wealth that is found in the bowels of the earth. Research must be directed towards finding out the materials that are deficient and supplying it to the soil. Research might also be directed towards finding out suitable crops for different soils.

It will not be out of place here if I point out what is done in China and Japan in order to improve the fertility of the soil. In our country all human excreta is wasted. In China neither human faecal nor urinary matter is allowed to waste. It is used in liquid, solid and powdery states according to the irrigation facilities and condition of the soil. It has been calculated that each family gets about two rupees per head by selling its excreta of nearly 900 lbs. In India we pay for excreta being removed. Whereas in China householders are paid for allowing their excreta to be carried away. You know in the Madras City alone our vast underground drainage system carries away all useful manurial stuff to the sea. It is calculated that by waste Madras City is losing Rs. 25 lakhs according to the pre-war values ; this will work to a crore of rupees according to the present day value of the manures. It is said that a Chinese farmer raises on half an acre of land cucumber that is produced in 4 acres of land in America. In addition to this, he also raises other crops in the same plot. Cultivation in Japan is so intense that the Japanese farmer pays individual alteration to almost each plant. Steps to infuse the same spirit into our agriculturists should be taken.

I cannot but mention at this Conference about the importance of the agriculturists and the shabby treatment that he is receiving at the hands of the world. Our ancestors have stated even in the Upanishads that water is the life giving power and food is that which gives the thinking faculty to man. It is only by concentration of thought that man is able to realize God. Knowledge prevades the whole world and some human beings attuned to the cosmic power in the world extract the secrets of Nature and give it to the world. But they cannot do so unless they have food. This was very well demonstrated by a practical example by Udhaluka and Swetaketu mentioned in the Upanishads. That is why also even the Tamil literature mentions that the man who gives food gives life. For producing food, the agriculturist needs land, water, cattle, seed and manure.. He needs the help of his fellow human-beings, of cattle, birds

and even insects. He gives his very life in order to produce the food on which all of us thrive. But every one else in the world, Labour, Capitalists and middle classes are crying for security. The agriculturist alone has no security. He is the play-thing of all the blind forces of the world. He is at the mercy of the rains. of his fellow human-beings and what is it that we give him in return ? Do we give him any security ? Does agriculturists get any protection or subsidy from Government as industry does ? Is there any assured water supply ? Is there any crop, cattle or famine insurance ? Does he get an assured market or price ? Has he got anything to look forward to ? It has been calculated that out of 72 lakhs of Pattadars in the Madras Presidency, about 66 lakhs have only uneconomic holdings. Therefore these 66 lakhs of Pattadars all the time have no other idea than to struggle to find ways and means of making both ends meet. How can any one thrive or be able to think of higher things while he has to wage his struggle for existence daily ? Have our scientists made all discoveries necessary to enable the agriculturist to carry on his agricultural operations with profit to himself and to others ? Have our Governments carried the knowledge which our scientists have extracted from Nature to the doors of the agriculturists ? Do they give them the necessary help to utilize those discoveries ? When are we going to have scientists like Burbank of California or Michurin of the Soviet Russia who working in the same field as Luther Burbank proved that under suitable conditions young hybrid seedings can be trained to develop any desired characteristics. Michurin took hardly wild plants from Siberia, Canada and various mountain regions and crossed them with delicate southern plants. The cross-breeds so obtained inherited all the hardihood of the wild flora. They resembled their delicate parents of the South in tastiness, brightness of colour, largeness of fruit. He evolved 300 valuable varieties of fruit. When are we going to have anything like the contribution of Soviet scientists in the matter of animal husbandry ? When are we going to progress in matters like vernalization of seeds and artificial insemination of cattle ?

We are astonished to hear that in the Karavayevo State Dairy Farm the yield of milk in 1938 was 6.15 tons per cow from 251 cows, that one particular cow has yielded 9 tons of milk and another cow which was reared on the same farm yielded 16.3 tons of milk during her sixth lactation.

Our agriculturist has to suffer for anything that he needs. Every thing comes from the raw products, body, mind, intellect, wealth, enjoyment ; but the producer of the raw products has no opportunity to build up his body or develop his mind and intellect or to accumulate wealth or enjoy anything in the world. How much effort does he put forth in producing the raw products ! But while the producers of raw products suffer the industrialists and manufacturers who only give a small change or turn to the primary products get all the best things in the world. It is on the labour of the agriculturist that you and I, all Governments, middle classes and industrialists are prospering. What are we going to give him back in return ? Have our Governments given any help to the agriculturists ? Do they give him the necessary credit facilities or agricultural implements

or manure or even do any research work and carry the results of the research work to him? The scientist must come to the rescue of the agriculturist by making newer and newer discoveries and the Governments must help the agriculturists by taking those discoveries to the agriculturists and also help him to utilize these new discoveries. We must all pay attention to items of constructive work suggested by Gandhiji and make the villages prosper. Let me hope that your efforts would succeed in bettering the lot of the agriculturists of this country."

The seventh meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India was held in Madras from the 7th to the 10th April, 1948.

The following attended the meeting :—

Members.

Sardar Bahadur Sir Datar Singh (Chairman).
Mr. M. S. Sivaraman.
Sri M. Ananthan.
Mr. M. C. Cherian.
Mr. N. Nallasenapathi.
Mr. K. Cherian Jacob.
Dr. J. A. Daji.
Capt. V. M. Chavan.
Mr. Jabir A. Ali.
Mr. L. C. Sikka.
Mr. S. C. Ray.
Mr. E. A. R. Banerjee.
Mr. B. M. Mittra.
Dr. N. C. Dasgupta.
Dr. B. K. Mukherjee.
Mr. Ram Surat Singh.
Sardar Bahadur Lal Singh.
Sri Jagdish Chander.
Mr. P. D. Nair.
Mr. R. B. Ekbote.
Mr. S. S. Selot.
Mr. P. M. Ganguli.
Sjt. Khagendra Nath Kakoti.
Sri R. P. Padhi.
Sri Banamali Patnaik.
Sri Braj Mohan Panda.
Rai Bahadur Kalidas Sawhney.
Mr. A. B. H. Khoorshid.
Mr. Abdul Majid.
Mr. Mohibullah.
Mr. Raghotam Reddy.
Mr. P. M. Narayanaswami Naidu.
Lt.-Col. C. A. MacLean.
Dr. V. N. Likhite.
Mr. G. S. Kulkarni.
Sardar Bahadur S. Harchand Singh.
Mr. T. C. K. Pillai.
Mr. Zafar Ali Khan.
Mr. M. Sankara Menon.
Mr. M. C. Joshi.
Mr. M. N. Lakshman Rao.
Mr. T. S. Venkatarama Ayyer.
Dr. J. K. Basu.
Dr. D. V. Bal.
Dr. J. N. Mukherjee.
Dr. B. P. Pal.
Dr. N. Parthasarathy.
Dr. T. J. Mirchandani.
Dr. P. C. Raheja.
Dr. E. S. Narayanan.
Dr. S. Swallhey.
Dr. P. Parija.
Dr. T. Sadasivan.
Mr. J. D. Manning.
Sri P. L. Narasimharaju.
Mr. N. J. Deshmukh.
Rai Bahadur R. L. Sethi.
Mr. C. C. Taylor.
Mr. J. C. Ramchandani.
Dr. H. S. Pruthi.
Dr. G. S. Cheema.
Dr. T. G. Shirname.
Dr. B. B. Mundkur.

Sardar Shamsher Singh.

Mr. B. S. Varadarajan.

Mr. R. D. Bose.

Dr. B. C. Kundu.

Mr. C. Ramaswami Naidu.

Mr. K. Gopalan.

Mr. K. C. Chetty.

Rao Bahadur Venkata Acharya.

Mr. K. C. Naik.

Mr. T. G. Menon.

Visitors.

Mr. C. R. Sreenivasa Ayyanger.

Sri S. N. Venkataramana Ayyar.

Sri G. R. Viswanathan.

Sri B. M. Lakshmipathy Murlidhar.

Mr. M. Kantiraj.

Sri C. R. Vijayaraghavan.

Mr. E. A. Lasardo.

Sri P. Venkataramaiah.

Dr. B. Natarajan.

Mr. K. C. Ramakrishnan.

Mr. C. M. John.

Mr. P. D. Karunakar.

Mr. R. N. K. Sundaram.

Mr. T. S. Ramakrishnan.

Mr. S. Ramaswami Konar

Mr. T. K. Balaji Rao.

Mr. R. Balasubrahmanyan.

Mr. D. Marudarajan.

Mr. P. Krishna Rao.

Mr. M. B. V. Narasimharao

Mr. T. J. Hurley.

Mr. S. Ramchandran.

Mr. R. N. Roy.

Mr. J. L. Mehr.

Mr. W. V. B. Sundra Ra[illegible]

Mr. S. Sen.

Dr. R. V. Tamhane.

Mr. Subbiah Mudaliar.

Mr. S. N. Kalyanaraman.

Mr. S. N. Chandrasekaran.

Mr. M. B. Venkata Narasinga Rao.

Officers of the I.C.A.R.

Mr. I. B. Chatterjee.

Mr. H. K. Lall.

Rai Bahadur S. C. Sarkar (Secretary).

AGENDA.

1. (a) The need for breeding crop varieties adapted to varying levels of soil fertility and for special conditions of soil and climate.

(b) Review of the work done on the maintenance of soil fertility in India with suggestions for future lines of work with particular reference to the effect of soil fertility on the nutritive quality, food & fodder of crops.

2. The importance of root stocks in the standardisation of fruit tree material.

3. Cereal rusts and their control.

4. Review of the comparative merits of different methods of improved farming practised in the country such as co-operative farming, collective farming, consolidated farming, joint management, consolidation of holdings, etc., with particular reference to improvement in the yield of crops and economic condition of cultivators.

5. Consequent on the division of the country, to consider measures to be taken, from the short-range and long-range point of view to maximise the production of food particularly of cereals in India, so as to reduce her dependence on imports to the maximum extent possible, and to suggest five-year targets of increase in such production for each unit of administration comprising India.

6. To review the measures adopted to increase the fodder production by :—

(a) selection and preparation of perennial cultivated grasses,

(b) improvements in rotational grazing, and

(c) exploration of new fodder crops in addition to improving the existing ones.

7. The rotation of crops which will give the best results in an irrigation intensity from 35 to 70 acres out of 100 acres.

SUBJECT No. I.

(a) The need for breeding crop varieties adapted to levels of soil fertility and for special conditions of soil and climate.

(b) Review of the work done on the maintenance of soil fertility in India with suggestions for future lines of work with particular reference to the effect of soil fertility on the quality of crop production,

The proceedings of the sub-committee are contained in Appendix No. 1.

In introducing the report Dr. Mukerjee said that the above two subjects dealt with actually two different matters though they had been included under the same heading. The first dealt with the need for breeding crop varieties adapted to varying levels of soil fertility and for special conditions of soil and climate. This subject was of great importance. There was a chronic food shortage in the country. but unlike Russia, where there was a vast expanse of potential arable land not yet brought under cultivation, the area of arable lands which had not actually been put under cultivation in India was very limited. It was therefore necessary to get the maximum productivity from the soil. For this purpose it would be necessary to ensure :

(i) that the variety of a particular crop which was grown in any region should be made to give the highest yield *i.e.*, it should be adapted to the characteristics of the soil and climatic conditions of that region, and

(ii) that the productivity of the soil must be maintained at the highest possible level. It was necessary to breed crop varieties which were adapted to varying levels of soil fertility and to special conditions of soil and climate.

It had been apparent to plant breeders that a crop variety which might do well in a soil of low fertility might not do so as well as in soils of high fertility. For instance, if 10 varieties of crops were taken and classified according to their performances on two soils having similar characteristics but differing in fertility, the chances were that the order of classification might be found to have changed.

In India the conditions of farming were not much developed. There was not sufficiency of green manuring or fertilisers and the limitations from which the peasant suffered were poverty and want of resources. It was necessary to ensure that the soil fertility was satisfactorily built up and maintained on a high level. The Committee took into consideration these aspects and they recommended that the crop varieties should be breed first to fit in with the regions which could be distinguished on the basis of broad differences in soil and climate. Secondly, in a given soil type since both conditions of average farming and high level farming might occur the breeder might direct his attention to breed plants to suit these two conditions. Then again it was necessary to remember that the varieties were to be grown both under rain-fed and irrigated conditions. The recommendations of the Committee were based on these considerations :

The Committee also considered it to be necessary to have an experimental station in each type of regions. Then there should be sub-stations under it where crop breeding experiments should be carried out. Most of the provinces and States had district farms and other types of farms. These should be developed wherever possible so that this type of work could be carried out satisfactorily. It was also necessary that adequate facilities in the matter of staff and equipment for the investigations should be provided.

As regards Soil Survey the Committee had before it a large number of notes from the members. On the Committee were represented both plant-breeders and soil workers from different parts of the country. The Committee discussed very thoroughly all aspects of the different points raised. It recommended the following resolution for the consideration of the Board :—

(1) That the plant breeder should keep in view :—

(a) that the variety had to be fitted.

(i) to the different regions which could be distinguished on the basis of the considerations of broad differences in soil and climate and in particular to each soil type ;

(ii) to rain fed and to irrigated conditions ; and

(iii) to different levels of fertility as obtained under average and high farming conditions ; and

(b) that the selected variety should also have power of resistance to adverse conditions such as drought, frost and pests and diseases.

(2) That experimental stations should be established in each of the region mentioned above and arrangements should be made for testing varieties in selected sub-stations or farms in each such region.

(3) That adequate facilities in staff and equipment should be provided for the investigations enumerated in item (1) (a) and (b) above as also for the necessary soil investigations,

(4) That rapid reconnaissance soil survey should be undertaken for each province and state.

Rai Bahadur R. L. Sethi, Agricultural Commissioner with the Government of India, said that the recommendations made that varietal trials should be conducted at individual centres had already been taken into consideration by the various Provinces and they were already doing this work. He desired, however, to draw attention to the case of the sugarcane crop. In the beginning the sets were provided by the experimental station at Coimbatore to various places. Objections were raised against the selections of the sets made at Coimbatore. These were sent to Karkal, Bihar and Shahjahanpur and they tried making selections at local centres. He himself carried out this work at Shahjahanpur and he found that even after all the work he did for 6 years. it was necessary to depend more on the sets obtained from Coimbatore

rather than the ones obtained locally or from elsewhere. The varieties available locally never gave anything better than that given by the Coimbatore ones. He could not say to what extent this work, on which so much stress had been laid would be justified. Too much stress should not also be laid on individualistic soil characteristics for evolving new varieties. If they were ever to produce varieties that could suit environmental conditions and other conditions it would be better to select varieties suited to definite soil areas and definite soil conditions.

He drew attention to the following passage from a note submitted by Mr. R. Balasubramaniam of Madras.

" A multiplicity of varieties must be avoided as far as possible and the work concentrated on improvements in soil management rather than breeding varieties having limited adaptability. Otherwise maintenance and distribution of improved seeds of the large scale production of commercially uniform quality would become almost an impossible task. In regions where shifts in planting time or cropping systems can successfully counteract climatic varieties or disadvantages, they must be fully experimented with, before trying to fit in special varieties.

In cotton, strains suitable for greater environmental diversity have been built up for both irrigated and unirrigated conditions. A wider hybridization programme involving the use of varieties subjected to long special and ecological isolation is likely to yield the required variability for applying selection to achieve this end. The utilization of hybrid vigour will do a very large extent serve the same purpose, especially in self-fertilised crops producing a large number of seeds per fruit ".

It was therefore necessary to look out for varieties to suit the different range of environmental conditions.

The other point was that the experimental stations in each region should be the centre of all experimental work on soils and crops pertaining to the regions and these stations should be used both by the Central and Provincial Agricultural Research Institutions in mutual co-operation. In the case of certain important crops like sugarcane or cotton, this sort of work was already being done. Taking the stations of the Provincial Governments say for cotton or sugarcane, Shahjahanpur, Mathura etc., they were already being used for this purpose and all the trials were being carried out in co-operation with the Central and Provincial authorities. There was therefore hardly any need for this sort of recommendation. He agreed that the item of work recommended by Dr. A. B. Stewart was worth taking up and should be pursued.

M. C. A. McLean, Commissioner of Agriculture, Baroda said that he was in agreement with Rai Bahadur Sethi. "Sir Albert Howard emphasized that there should not be a multitude of varieties because too many varieties were apt to confuse the cultivator, and no variety should be pushed out that was not ten per cent. than the one that it was going to replace............ ". With a large number of stations scattered all over India, producing a large number of varieties, the poor ryot would be flooded with an extensively large number of varieties with which he

would not know how to deal. The proposal here was to put adaptability right at the end of the table. It was necessary to have a variety that would be adaptable to high and low fertility and to irrigated and non-irrigated tracts. If the plant breeder was going to cater for an extensively wide circle, the number of varieties that would suit these conditions would be large and would put a greater strain on him.

He cited the instance of a variety of wheat which had initially been obtained from Pusa in Bihar. This variety was growing under irrigated conditions in Baroda whereas it was grown under non-irrigated conditions at Sepaya in Bihar. He did not therefore approve of this multiplicity of stations working on a large number of varieties. It had been stated that the varieties selected should be resistant to drought, frost, pests and diseases. One thing that every variety should have and which was not mentioned was good cooking quality and that was the most important consideration. Many years ago he was given, probably by late Dr. Shaw, some varieties of Arahar which were neatly labelled A, to K and he was asked to test them. He made the first test by giving them to some clerks and farm overseers. Some varieties produced a good *dhal* but others produced a dhal which was not acceptable to the people and therefore the question of the cooking quality of varieties selected must be always kept in the foreground. As regards the question of establishing stations and sub-stations in the regions (presumably soil regions) there were 10 climatic and 21 soil regions at the present moment, and the discussion was rather anticipating the regionalization of research in India, which was a subject they would have to deal with separately. He agreed, however, that there should be a rapid soil survey. Such a survey should be conducted as soon as possible.

Dr. B. K. Mukerjee, Director, Central Sugarcane Station, Shahjahanpur, said that there was much force in the argument that there should not be a multiplicity of varieties as that would be too confusing to the cultivator. In certain cases however, it became necessary to adopt a different course of action. While agreeing with R. B. Sethi in what he had said about the Coimbatore variety of Sugarcane, he desired to point out that the difficulty mentioned occurred about 10 years ago. For years Coimbatore 313 had been the most successful variety in Bihar. Similarly, Coimbatore 312 had been the principal sugarcane variety for the U.P. But after all these years of concentrated work on the part of the Agronomists and plant Breeders it was found that today C0313 was a curse to Bihar ; similarly, C0312 might be the same in U.P. No one would question the usefulness of the work done by that station but the point was that the varieties evolved at Coimbatore would not for all time suit Northern Indian conditions. It was therefore necessary to change the entire outlook of breeding of sugarcane in order perhaps to save the sugar industry of U.P. and Bihar from a serious crisis. There were slight difference, as far as he knew, between, say the breeding of wheat and breeding of sugarcane. Now, in the Committee presided over by Dr. J. N. Mukerji they discussed all these things in great detail and spent a lot of time in framing these definite recommendations. While dis-

cussing those points they certainly laid a lot of stress on the case of sugarcane. Now the present method of evolving sugarcane varieties was based intrinsically on bringing together all parents the progenies of which were calculated to ensure the desired characteristics. But sugarcane was hytrozygous and the innumerable seedlings from individual flowers had individual characteristics and it was necessary to select at random a number of so-called varieties out of a large collection of seedlings. For this purpose the first necessity was to make a sort of visual selection and then the work might be continued for a number of years to find out the chemical and physiological characteristics of the varieties. That meant that for a long period they were to take a chance without knowing whether the whole work would lead to any-where. On the other hand, if they confined the breeding work to distinct soil-climatic-zones, there would be a greater chance of attaining success in a shorter period. There was another serious agronomical aspect which should also be considered. Importance was being laid on the application of more and more fertilisers but unless discreet and adequate use of fertilisers was made the object of maximising production could not be achieved. Then it was necessary to ensure that such use would be economical. No cultivator would touch any fertiliser unless and until he found it to be paying. For one pound of nitrogen one particular variety might show much more response than another variety. Therefore it would be shortening the whole course of varietal work if they kept in view from the very beginning the need for breeding crop varieties which were calculated to give the highest out-turn per lb. of nitrogen added. In his opinoin each soil tract within a particular climatic belt should form a unit for work on breeding and selection. Plants in a particular soil attain equilibrium with environmental condition. Therefore the success of obtaining the desired varieties by breeding would be much greater if the breeding work was actually done under local soil climatic conditions.

Mr. M. Ananthan, Deputy Director of Agriculture, Madras said that there were tracts containing different pockets which had soils of different types and in the same farmer's holdings there were fields of high and low fertility. There should be scope for breeding not only strains suitable for a very wide tract but within the tract itself suitable for different pockets of soils of high and low fertility. There might be selections from the same variety but the culture or the unit strains might have different capacities for yield. For instance, they found that some of the rice strains they had evolved in Madras did not stand very high manuring because disease broke out. There were cases where they had to select strains to stand up to different conditions of manuring or climatic or irrigational features. They had grown nearly 1500 varieties in Madras and nearly 55 lakhs of acres of land had been covered by about 132 strains. That was a very small number when compared with the huge number of varieties that were now under cultivation. This question of multiplicity was raised at every conference but so far they had not been able to provide cosmopolitan strain in any of the

delta i.e., tracts where controlled irrigation water was available. Coming to rain fed tracts a dozen varieties were being grown to study the climatic aspect in the fields such as the thickness of the soil, the level of the soil and the existence of the moisture. All these conditions were there by nature and they found that there were hundreds of varieties grown in the rain fed tracts. Coming to cotton he was not sure whether it had been possible to evolve a strain to suit all conditions. For instance, in the Tinnevelly District they had Kl quality which covered about 8,00,000 acres or so, but they had not been able to push that Kl to the Eastern part of the tract though every cultivator there knew that Kl was a very good strain and had done well They had recently got a strain 4,206 which was now replacing the other cottons in the eastern tracts of the district. This cotton, though grown under dry rain fed conditions could not be fitted in the northern or the eastern tracts of the district. There were special types of cotton. Of course, nobody would be happier than the plant breeder to have cosmopolitan strain but it would be generations before they could think of that. There was another strain called Kambodia but it had not been a success. Even in cotton they had not come to that stage when they could say that there was a strain that would stand everywhere and every climate.

With regard to the question of finding out strains that could resist diseases under low and high fertility they had to think of breeding disease resistant strains. In Madras they had evolved in a strain in Coimbatore called K4. It was a variety grown in the romal tract of Coimbatore. They were now trying to put the strain of K4 into all strains. There was a strain in Tanjore District which was occupying about 4 lakhs of acres but unfortunately when blast disease appeared in an epidemic form that strain was unable to stand the disease. There were at least two strains now that could be considered as immune to blast disease and they were multiplied.

The Chairman said that the previous speakers had laid stress on two aspects. one was the multiplicity of breed and the other was the reorganisation and multiplication of regional stations It would be better if the speakers could confine their remarks to these two aspects so that it might be possible to arrive at an early decision

Mr. Chavan, Deputy Director of Agriculture, Bombay said in regard to multiplication of centres they had started with three centres on rice alone in Bombay and at present there were fifteen centres It was not because they wanted to multiply the centres but it was a necessity. They found that in rice tract there was a great variation, rainfall varying from 40″ to about 100″. Taking all factors into consideration they found that the three stations on which they were working were not at all sufficient and hence they had to increase the number. It was absolutely necessary to have all the fifteen stations because the strains evolved at the main central station were not at all adequate to satisfy other regions.

Sri Kalidas, Sawhney, Director of Agriculture, Hyderabad Dn. said that the recommendations made by the Committee were in no way revolutionary or such as could be seriously objected to. One recommendation was that the varieties should be fitted to the different regions which could be distinguished on the basis of differences in soil and climate ; another recommendation was about reducing varieties suited to rain-fed and irrigated conditions and the third related to different levels of fertility as obtained under average and other conditions. The Committee had merely reiterated the practice that was already being followed by practically every plant breeder worth the name. If they took the case of rice for instance, it had been pointed out that hundreds of varieties and types had been produced to suit different conditions, different areas, different soil types and different climatic conditions. There were medium, coarse, fine, early-maturing types, medium-maturing types and late varieties and so on. There might be certain types resistant to different pests or diseases. In all crops like wheat, sugarcane, cotton etc., the plant breeders had all the time been trying to produce varieties suited to various types of soil, and climate or differently distributed rainfall, or rain-fed conditions or irrigated conditions. It had also been suggested that types that suited to different levels of fertility should be produced as cultivators used different quantities and different qualities of manures. Therefore, there could be no serious objection to these recommendations. Perhaps too many strains had been evolved and the plant breeder should be asked to exercise a little more the art of rejection than the art of selection.

Another recommendation made was that the selected varieties should be such as would be resistant to adverse conditions such as drought, frost and pests and diseases. Every plant breeder was already paying full attention to this. As regards having a number of research stations, no hard and fast recommendations could be made by the Board. It should, however, be emphasized that sufficient facilities should be provided in areas with definite differences of soil and climate for breeding work or for extending the breeding work to meet the requirements of those regions and climatic tracts.

There should be a plant breeding station for rain-fed areas and another for irrigated areas. It might also be possible that at one of the stations facilities might exist for irrigation even if that station was located in a rain-fed area. In such cases no new stations need be established. It was important to have provision of facilities for testing the types in different regions under cultivators' conditions.

With regard to the final recommendation that a rapid reconnaissance soil survey should be undertaken for each province and State the position was that most of the Agriculture Departments had done it already. This recommendation should be addressed to those who had not done so as yet. Detailed soil survey would have to be done especially in areas where new projects were contemplated.

Mr. Parthasarathy, Geneticist, Indian Agricultural Research Institute said that they had to find out the limits under which a particular variety would do well or not. Experience had shown that a few varieties would do very well under certain conditions, but that the same varieties would be a failure in some other places where poor varieties would do better. India was a land with varying ranges of soil and climate. If one thought of evolving a strain suited for all requirements it would be an impossible task. As regards sugarcane they had already evolved nearly 500 varieties upto 1940 but there were not even a few varieties which suited all places.

Dr. Bal, Director, Institute of Plant Industry, Indore said that as regards multiplicity of varieties there were a number of crop-breeders and Botanists on the committee to give guidance in regard to the work in different parts of the country. It has been stated that by starting these various soil and climatic region work, they were increasing the number of varieties. In his opinion they were actually reducing the number of varieties. If they took a crop like cotton, they would find that in Bombay Presidency they had nine to ten varieties, in Madras 7 varieties, and about a dozen varieties or more in the Punjab, U.P. and other regions in addition to an equally large number of varieties of other important crops. If they limited the work on the basis of the 21 soil and climatic zones mentioned in the note circulated and if the plant breeder could give varieties suited to these areas, the result would thus be to reduce the number of the existing varieties. The substations were not to undertake work of selections or breeding but were merely to try the varieties which were evolved at the main central Stations, in the crop climatic and soil zone.

Dr. J. N. Mukerji said that the main difference of opinion seemed to be as regards the question of multiplicity. As one speaker had pointed out they might have ultimately a much smaller number. On the other hand it was quite possible that they might find that it was worth while on economic grounds to have a larger number. He invited attention of the members to page 2, 2nd para. which read as follows:—

> "The Committee recognize that the position may vary as regards different crops and in some *e.g.*, cotton practical difficulties might be encountered; but the need for breeding varieties suited to high level farming conditions should not be lost sight of. In contrast to cotton, however, millets are less cosmopolitan and more conservative than other crops and here the need is all the greater to fit the variety to the soil type".

He said that the Committee noted the circumstances that led to this point; in some cases the practical difficulties might be more and in some cases less. They came to an unanimous conclusion.

As regards regional station it was recommended that "an experimental station should be located in each of the regions determined by broad differences in soils and climate". India was a vast country. The

area under cultivation in the whole country was 1,000 million acres. There were 21 regions. There were many parts where there were no experimental stations. It could not be the intention that no experimental station would be located for instance in Rajputana. As regards establishment of stations and sub-stations, the Committee thought that the stations should be located in recognized climate and soil regions wherein all work should be carried out and that it was necessary either in respect of scientific efficiency or economy, to multiply the stations.

The Chairman said that the opinion of the house seemed to be that they should adopt these recommendations. The suggestion made by Mr. McLean, that the cooking qualities should be kept in view might be accepted.

The following Resolutions suggested by the Committee, were then adopted by the Board:—

"(1) That the plant breeder should keep in view

(a) that the variety has to be fitted

(i) to the different regions which can be distinguished on the basis of considerations of broad differences in soil and climate and in particular to each soil type;

(ii) to rain-fed and to irrigated conditions ; and

(iii) to different levels of fertility as obtain under average and high farming conditions ; and

(b) that the selected variety should also have power of resistance to adverse conditions, such as drought, frost and pests and diseases.

(2) That experimental stations be established in each of the regions mentioned above and that arrangements be made also for testing variesary soil investigations, be provided.

(3) That adequate facilities in staff and equipment for investigations enumerated in item (1) (a) and (b) above as also for the necessary soil investigations, be provided.

(4) That a rapid reconnaissance soil survey be undertaken for each province and State.

Dr. Mukherjee then introduced the report on subject No. 1(b). In doing so he said that as regards the quality of crop production certain difficulties had been experienced as the quality varied from crop to crop, commercial factors came in and sometimes it was very difficult to define quality. The Committee, therefore, considered the question of nutritive quality and made specific recommendations regarding that aspect. Some legumes were very good green manures and modern Scientific experiments showed that green manures and grasses were of great importance in improving and maintaining soil fertility. The question was whether it was necessary to have a better type or whether it was necessary to have extensive use of green manures. The Committee recommended both. These legumes in crop rotation were very important in building up soil

fertility. That was a question in which knowledge was lacking. It was necessary to study indigenous and exotic legumes. There was scope for a large amount of work for research in this respect. An attempt should be made to introduce legumes which would do well as green manure, fodder crop, catch crop or cover crop and to fit them in the different soil regions and the crop systems. The influence of green manure on paddy had been found to be very good. Moreover there was a gap of several months between the harvesting of one crop and the sowing of the next one. There was thus room for fitting in legumes. The Committee reviewed all aspects and then laid down certain specific resolutions. During the course of discussions it was mentioned that a large amount of sub-marginal lands was being put under cultivation. In the opinion of the Committee this was not desirable.

The Committee was of the opinion that the suitability of land for growing crops and trees or for pastures should be determined. Otherwise the soil would be lost by erosion. That was why it had been recommended that a land use classification was necessary. It was now a universal practice to have a suitable legume or legumes, in crop rotations and also for enriching the soil fertility. As regards artificials there was always controversy. The view was held that artificials definitely ruined the soil. It was however a regular practice in Europe and America to have a dressing of PK along with Ammonium Sulphate. Sufficient quantity or organic manures was not available in this country. Green manures were good but the world was using something like 9 million tons of artificial fertilizers. In this country also the mis-uses of artificial fertilizers were not unknown but it was necessary to examine the results that were being obtained so that any risk in their use might be avoided. The Committee's recommendations were based on the above considerations Dr. J.K. Basu, Soil Physicist, Bombay, said that although, he was in general agreement with the resolutions drafted by the Committee, he could not help feeling that there were some important omissions. The Committee had thoroughly dealt with the subject of manurial schedules for the maintenance of soil fertility, but amongst the aspects left out, one was the tillage operation which was one of the important operations required for the growing of crop and which in many cases resulted in deterioration of soils when carried to excess. This aspect had not been thoroughly worked out any where in India. The experiment on tillage had been conducted for a very short period and the data thus obtained were not reliable for recommendation to cultivators. As regards the recommendation regarding frequency of ploughing they had got no data to go by. There were some data at his station farm to show that repeated cultivation resulted in deterioration of soil fertility. He suggested that they should include in these resolutions, a recommendation regarding experiments on tillage operations for proper time and frequency of operations.

The second omission was the absence of any recommendation about the Soil conservation methods to be adopted for general practice of maintaining sub-soil fertility. This was a very important subject and he had pointed it out in his note that wherever there was the practice of arable

farming, the soil losses were very very great. That meant that if they did not take any precaution regarding protection of soil fertility, the fertility would be lost within a few years. They also found during their main survey in certain districts in the Bombay Province that over 70 per cent of arable land was lost partially or wholly. In view of this important nature of the problem he recommended that the Board might include the following resolution also:

"In view of the fact that erosion has been found to be of serious magnitude in arable farming in certain parts of India, it is highly desirable to recommend suitable erosion control measures to different land classes used for cultivation purposes in all Provinces and States. In this connection biological methods of control *e.g.*, strip cropping, should receive greater attention as they are cheaper and easier to follow".

Dr. Mirchandani, Head of the Division of Agronomy, Indian Agricultural Research Institute, said that the subject of soil fertility was no doubt very important and the resolutions brought forward by the Committee were thorough. He wanted to mention one little point that might be considered and that was that the yield of crops per acre was slowly going down in spite of the increase in the production. The increase that had been obtained was due to the increase in the acreage and not increase in the yield per acre. This was, no doubt a very disturbing factor which was associated with the soil fertility problem. It was time to find out why it was that the yield per acre was not going up? Was it because they were tapping the land to poverty ; was it that they were not looking after the stock trial of other portions in the land or was it that the crops that they were growing were taking more from the soil than they were returning to it ; in other words was it that the land was generally getting tired? If they could only enquire into this problem and try to find out the causes that were responsible for the less yield, possibly they might be able to find a remedy. There was no doubt that they wanted to maintain and build up fertility. At the same time it would help considerably if they found out the causes which led to the lowering of fertility in spite of all efforts put in for improvement. In this connection he would like to draw special attention to Resolution No. 2. of the Committee, not that it was in any way more important than others but he considered personally it necessary to draw pointed attention to it The principle of crop husbandry should be such that the land should not get tired and should continue to remain in good condition and that could be achieved by a suitable rotation of crops so that if this resolution in principle was given immediate effect they should know very soon why the land was not yielding enough.

Mr B. K. Mukerjee said that the recommendations made were very comprehensive and he would urge upon the members to accept them *in toto*. But a very important point had been just now brought out by his friend Dr. Basu of Bombay. It was undoubtedly true that unless they took effective measures to stop the tremendous amount of sheet erosion which was going all round the country it would be impracticable and unscientific to take recourse to any intensive planning of applying artificial fertilizers and organic manures to cultivation. It was quite all right to

secure large yields by the application of manure but unless and untill they kept the surface soil profile in a proper condition it would be impossible to gain the desired end. Therefore, a certain amount of modification was necessary and the aspect of some anti-erosion work in Item 2 of this recommendation should be included.

Mr. I. Chatterjee, Assistant Agricultural Commissioner with the Government of India, invited attention to recommendation No. 4 in which it had been stated that more systematic investigation should be carried out with different forms of organic manures, especially green manures, farmyard manures, compost, either alone or in conjunction with artificials. He suggested that in place of "either alone or in conjunction with" they should include both. This was agreed to.

Mr. I. Chatterjee further said that another point was that as regards farmyard manures they should take into account the application of nitrogen and other nutrients per acre of soil. The suggestion was accepted.

Rai Bahadur R. L. Sethi said the first resolution on item 1(B) viz. "that a land use classification should be carried out to determine what areas are suitable for growing crops or trees or for pastures", appeared to him to be a very elementary sort of recommendation. He was glad that the Chairman of the Committee had explained that it was not required to be taken up for all the land but for the sub-marginal areas where the distinction was to be made as to what area should be suitable for that purpose, and what area for the trees.

Regarding the second point with regard to the maintenance of soil fertility treating irrigated and rain fed areas separately, he said that action had alreay been taken by the Indian Council of Agricultural Research on the report of Dr. Stewart which was very comprehensive and the scheme was already in preparation and all these aspects would be taken up. In connection with the recommendation that the fixation of phosphate and placement of fertilitizers especially phosphatic fertilizers should also be investigated, the position was that a scheme had already been sanctioned in this connection by the Indian Council of Agricultural Research on the recommendations of Dr. Stewart to study these factors. Comprehensive work to find out the effect of fixation was to be taken up and a scheme sanctioned for the purpose.

He quite agreed with the recommendation No. 4 that more systematic investigations should be carried out with different forms of organic manures especially green manures, farmyard manure and compost either alone or in conjunction with artificials. Even in Madras he understood there was a difference between the effect of the different qualities of crops with the application of organics. There would be no harm in adopting the suggestion that the investigations should be carried out with different forms of organic manures.

He also agreed with Dr. Basu that although soil conjunction work progressing, a recommendation to that effect should be made, as bunding and strip cropping were giving very good results in Sholapur. They might recommend that this work was of a nature that the Indian Council of Agricultural Research should take up It was very important and should be

taken up as a separate recommendation in the form of a resolution. Dr. Keen's suggestion of applying nitrogen and organic manures to the crops was very important. A system of crop husbandry should be adopted in India by which they could get very good increase in the yields and increase the soil fertility. A scheme was mooted for seeing the effect of Ammonium Sulphate by Mr. Subramanyan from Bangalore and Indian Central Cotton Committee sanctioned the scheme. The next point was that they should evolve certain systems of crop husbandry and in that way they would be considerably helping fertility.

Dr. P. C. Raheja, Agronomist, Indian Agricultural Research Institute said that the idea was to have a review of the work done on the maintenance of soil fertility in India with suggestion for future lines of work with particular reference to the effect of soil fertility on the quality of crop production. No resolution had been presented to this Board showing the review of the work done on the subject. It had been brought out by the experimental work in the Indian Council of Agricultural Research that mixed crop experiments definitely increased the fertility of the land and also raised the status of the farmer in respect of his economic conditions. This idea of mixed cropping should be brought out in these studies.

The Chairman said that there did not seem to be much difference of opinion as regards the recommendations made by the Committee. One or two small points had been raised. Emphasis had been laid about the organic and inorganic manures. In Resolution No. 3 it was stated that "manurial schedules for the maintenance of soil fertility should be worked out, treating irrigated and rain-fed areas separately. The different forms of nitrogenous and phosphatic manures should be studied in detail. Also, in manurial experiments a comparison should be made of N, NP, NPK treatments at different levels. The fixation of phosphates fertilisers and placement of fertilisers especially phosphatic fertilisers should also be investigated", and in Resolution No. 4 it had been suggested that "more systematic investigations should be carried out with different forms of organic manures especially green manures, farmyard manure and compost, either alone or in conjunction with artificials". He had suggested to the CHAIRMAN of the Committee that instead of saying 'either alone or in conjunction with' they should say 'Compost alone and in conjunction'. That would put the matter right. The Chairman had agreed to the suggestion and this might be accepted.

Regarding Rai Bahadur Sethi's remarks about Dr. Keen's recommendations, the note had been discussed by the Committee. He invited the Chairman of the Committee to make a statement on erosion which point had been brought out by Dr Basu.

Dr. Mukerjee said that as regards erosion and sheet erosion, the Committee did not want to go into question in detail. An indication had been given as to the use of land classification and he had made a reference to that Item No. 1.

Erosion was a big enough subject and the effect of sheet erosion on soil fertility was known but they should not smuggle those big subjects into this specific issue. A Sub-Committee was appointed to consider this question in 1937 or 1939 by this Board when the question of erosion was

gone into very thoroughly and definite resolutions were adopted. The need of an All-India erosion survey had then been pointed out. The appointment of Erosion Committee in the Provinces and States and in the centre for co-ordinating work and many other relative points were discussed in those resolutions.

The Chairman enquired if it was the idea that they should bring to the notice of the provinces and states the importance of erosion control. The house was in favour of the suggestion.

The Chairman said that it had been suggested that in Item I (b) the heading should be slightly changed. In the last line in place of "Soil fertility on the quality of crop production" it should read "soil fertility on the nutritive quality of crops and fodders". The whole paragraph as amended would be as follows:—

1(b) "Review of the work done on the maintenance of soil fertility in India with suggestions for future lines of work with particular reference to the effect of soil fertility on the nutritive quality of crops and fodders".

The Board then agreed to the above suggestions and adopted all the eight resolutions fromed by the Committee with a slight amendment in Resolution 4 to read "compost alone and in conjunction" for "compost either alone or in conjunction" as follows".

(1) That a land use classification survey should be carried out to determine what areas are suitable for growing crops or treek for pastures.

(2) That suitable crop rotations in which legumes that build up soil fertility are included should be evolved to fit the different soil climatic regions and cropping systems. Both indigenous and exotic legumes should be studied ; their usefulness as cash, catch, cover, or fodder crops, or for inclusion in mixed farming taken into considerations.

(3) That manurial schedules for the maintenance of soil fertility should be worked out, treating irrigated and rain-fed areas separately. The different forms of nitrogenous and phosphatic manures should be studied in detail. Also, in manurial experiments a comparison should be made of N, NP, NPK treatments at different levels. The fixation of phosphates and placement of fertilizers especially phosphatic fertilizers should also be investigated.

(4) That more systematic investigations should be carried out with different forms of organic manures especially green manures. farmyard manure and compost alone and in conjunction with artificials.

(5) That soil organic matter should form an important subject of investigation specially in relation to its effect on soil structure and on microbiological activity.

(6) That microbiological investigations should be given more importance and attention should be paid in this connection to the role of Azotobacter in soil fertility:

(7) That in relation to nutritive of crops, systematic chemical analyses should be done. Where facilities are lacking at present, at least N, P, K, Ca, ash, and carbohydrates should be estimated. The main experimental stations in each province or state should be fully equipped to carry out comprehensive investigations on the nutritive value of selected crops.

Biological assay of nutritive value of crops should be carried out in conjunction with biochemical departments of universities or other institutions

(8) That a rapid reconnaissance soil survey should be immediately carried out in each province and state on the lines indicated in the resolution of the crops and Soils Wing of the Board of Agriculture in 1936. The recommendations made by Dr. A. B. Stewart as regards soil and agronomic studies should be implemented as early as possible".

SUBJECT NO. 2.

The importance of root stocks in the standardisation of fruit tree material. (For proceedings of the Sub-Committee dealing with subject No. II vide Appendix II).

Dr. G. S. Cheema, Fruit Development Adviser to the Government of India who was the Chairman of the sub-Committee introduced the subject and said that, in order to make fruit growing very profitable in India, the standardisation of plant material was absolutely essential. The main object in underlying standardisation was to ensure a larger percentage of uniform productive trees of quality in a unit area. A good deal of work in standardisation of material had been done in the case of temperate fruits ; so the task in regard to such fruits was comparatively easier but the standardisation of citrus, mango and similar tropical fruits involved a good deal of further research as their standardisation had to be brought about by several methods, including tree and bud selection and roguing of variants from polyembryonic material. It was essential that root stocks and scion investigation should be taken up by all the provinces and states wherever these were largely grown. Meanwhile, with the help of available knowledge it should be possible to help the fruit growers to a certain extent. The discussions of the Committee on these questions were summarised in the preamble which had already been circulated. The Resolutions as drafted by the Committee were for consideration.

Mr. Naik, Fruit Specialist, Madras said that the Committee's views were that the efficiency of fruit orchards in the country was miserably

low. Work done in some provinces had clearly shown that while one should expect cent per cent inherently fruitful trees in the plantation, hardly 10 per cent of regular fruit-productive individuals were found. So long as the position continued to be like this no progress could be achieved, however, much they might strive in other directions. This subject was therefore of great importance, because it provided the one means by which they could increase effectively the profits from the fruit orchards. Planting of cent per cent inherently fruitful trees provided the key for success in orcharding. For this they must examine the possible ways of increasing their orchards efficiency. The Committee attempted to show that the methods of achieving this orchards efficiency lay mainly in three directions; firstly by arranging for effective selection of trees so that they might have progenies only from parents of known performance and from varieties which were already acclaimatised. This implied a careful survey of the existing orchard material to select trees of outstanding merit. The next was by attempting to work on the lines of bud selection on which very notable improvements had been effected particularly in the U.S.A., South Africa, Australia and other countries. The work done by Shamel and his coworkers showed that in several notable clonal strains the performances were not alike. Therefore, by the indiscriminate selection of buds they were getting only a preponderence of unfruitful or uneconomical orchard elements. The nurseryman who did not realise the value of bud selection, might intentionally or otherwise be selecting buds which were intrinsically unfruitful or of poor quality. This emphasised the paramount need for bud selection. The third step, of course, was by the selection of rootstock. It was well known what important influence the rootstocks exercised on the scion performance.

It was necessary not only to have an intrinsically high clonal strain as a result of tree and bud selection but there must be effective stionic combination which would give the best orchard performance for every major cultivated fruit in the important fruit growing zones. It would, therefore, be pertinent to mention here that through the selection of efficient clonal strains, orchard efficiency had been increasing in recent years. Very recently in England, the Ministry of Agriculture passed a legislation to permit the planting of only high yielding clonal strains from individual strawberry plant selections. The examination of the performance of individuals in several centres disclosed that the progenies of different plants behaved very differently. It was, therefore, felt that rigorous selection of individual trees was of crucial importance in securing effective planting stocks for the orchards. In several countries spectacular improvements had been effected as a result of these methods and their implementation had been done on a wide scale. Lastly, horticultural history was full of instances of spectacular improvements that had been effected by the determination of the optimum scionic combination and therefore, all these methods were of great importance in improving the efficiency of orchards and in increasing the profit. But all these would be of little avail if they did not regulate the private nursery trade. At present, it was a matter of common knowledge that the private nursery trade was only anxious to multiply its nursery stock and sell them at the best bargain possible. There had been instances where agents had been

going on and canvassing for a particular specified variety and selling plants entirely under spurious names. Foreign workers had said that several varieties said to exist in the nurseries in India, existed merely in the imagination of the nurserymen and they had expressed the view that it was futile to import nursery stock from India. In the interest of the fair name of the fruit industry therefore it was essential that they should safeguard the fruit grower from the various malpractices that existed at present. Therefore the registration of fruit nurseries, was considered to be of great importance in order that only plants of genuine quality could be selected from the trees of best performance and raised on optimum.

S. B. Lal Singh, Director of Agriculture East Punjab, said that no crop in India had such scope for improvement as the fruit Crop. The very fact that there were gardens in every province yielding as high as Rs. 2,000 to Rs. 3,000 while others were not yielding even a hundred rupees per acre showed the scope for improvement in gardening. One factor responsible for the low income or low yield was the planting of inferior varieties of plants. Purchase of plants was largely a gamble for a fruit grower as he could never be certain from the look of the plants alone in the nursery that they were of reliable or standard variety. Everything depended upon the word of the nurseryman and after long years of toil and labour the grower may find that he had been cheated and tens or thousands of rupees for purchasing the plants and bringing them to bearing age were wasted. He felt that the Committee should have gone a little further. In every civilised country legislations have been enacted to control the nurseries. During his visit to Australia last year he found that it was an offence to start nursery without a licence and the nurserymen had to undertake to produce plants of specified varieties only. approved by the Department. This ensured to fruit growers the supply of plants of right types and free from disease. Unless and until nurseryman's guarantee was forthcoming, he could not ply his trade and heavy penalty was imposed by law on the non-compliance of rules by nurserymen. In Egypt. America and Europe similar laws were enforced. It was time to enact rigid laws in India and no nurseryman should be allowed to start a nursery unless and until he conformed to certain specified conditions. After-all no nurseryman should have the right to ruin the fruit industry for the sake of his personal gain. Mere registration of fruit nurseries would not go far. This experiment of registration was started twenty years ago in the Punjab, according to which the names of nurserymen guaranteeing to produce plants of reliable varieties and fulfilling certain conditions were to be registered and these nurseries were to be inspected from time to time. But this proved a failure as there was not sufficient staff to go round to check the nurseries. They could not place an Agricultural Assistant or Inspector at each nursery, especially at the time of budding to ensure that the plants were being budded with the right type of bud-wood only. Thus ultimately the whole thing had to be left to the good sense of the nursery-men, many of whom unfortunately did not prove reliable. He, therefore, felt that it would be proper to go a step further and enact suitable legislation.

Mr. Jabir Ali (Bombay) said that the greatest difficulty at present in the development of fruit growing was that both the Central Government and the Provincial Government refused to believe that fruit growing as an industry required help from them. He suggested that the recommendation should be amplified by adding to it one sentence at the end as follows:—

> "This Committee believe and would like the centre to accept that fruit is not only a food but it is one of the most important foods and every help that is being given to growing of grains and other crops to-day should also be given to fruit crops as well."

The Chairman pointed out that this aspect had been included in the Resolution of Committee No. V and if so desired, the matter might be examined in that connection. Mr. Maclean said that there was recommendation from the India Council of Agrl. Research sometime ago that demonstrational orchards should be set up in the provinces. He did not know how many provinces had gone ahead with it. Baroda and Gwalior were doing something but he would like the recommendation to go forward for the establishment of demonstrational orchards by the provinces and states as soon as possible. He further said that one of his friends in Baroda established a mango orchard and brought all his grafts from Navsari inspite of the fact that Government Department had fruit orchards spread throughout Baroda. It was difficult to find why he should have gone to private nurseries with all the attendant dangers when there were Government orchards. He therefore suggested that if it was within the competence of the Committee, it should ask the Government of India to press on all the states and provinces to establish demonstrational orchards.

Dr. Cheema said that he welcomed the suggestions made by S. B. Lal Singh and Mr. Maclean. A fine system of registration of nurseries existed in Germany as late as 1939 in which the German nursery men were registered on a voluntary basis. They had their own tribunal which prescribed certain standards for all kinds of fruits. The defaulters were punished heavily by that tribunal. This system was working wonderfully well. It was for consideration if this country had come to that stage where voluntary registration was possible. He would not object to the proposal of S. B. Lal Singh regarding legislation provided it was in the interests of the cultivators and they welcomed it. As regards the suggestion of Mr. Maclean that demonstrational orchards should be started in all provinces and states he felt that this would be very desirable. Uptill now the provinces and states did not pay sufficient attention to the development of fruit industry. It was on account of this that uptill now no province had been able to establish demonstrational orchards and if they did a little, it was not up to the mark. He was strongly in favour of making a recommendation to the provinces and states that they should go for demonstrational orchards. They could add to the resolution as follows:—

"They should raise model orchards with their improved stocks in the first instance before proceeding further."

The Chairman said that it seemed to be the view of the house that the two suggestions made by S.B. Lal Singh and Mr. Maclean should be accepted. If so, the Resolutions as amplified would stand as follows:—

"The Board while recognising the supreme importance of standrdised material in raising profitable orchards recommends that:—

(i) Towards this end, work be planned in several directions. This would involve firstly, the selection of trees in acclamaitised varieties on the basis of actual orchard performance and secondly, the selection of bud in order to eliminate off types from future orchards. These have to be supplemented by the determination of an optimum stionic combination for each important region and in respect of each of our major cultivated fruits. The provinces and states may therefore plan comprehensive trials to cater for each of the major areas, and these schemes may later be scrutinised by the Centre. In the case of other fruits, wherein rootstocks are considered to be of no significance, standardisation will naturally be effected through only plant selection, supplemented by careful rouging out of variants in nursery stage.

(ii) As a direct means of help to the fruit growing industry, and pending the results of trials suggested above, an effective means be devised to provide efficient and standardised material for the new plantings as well as to fill the gaps in the existing orchards. Such an objective can be achieved through the regulation of the private fruit nursery trade as well as by concerted propaganda by trained horticultural workers on the basis of available knowledge.

(iii) In this connection, registration of fruit nurseries should be deemed as a work of urgent importance since on this depends the supply of reliable plants of intrinsically high performance.

(iv) The Government may be requested to enact legislation of nurserymen enjoining that nurseries must conform to the standards as laid down in the preamble and no nursery man could start a nursery unless it came to this standard.

(v) The provinces and states should establish Demonstration orchards and in order that the parties could be assured of dependable materials the grafts etc. should be supplied from this source.

The Resolution as amended was adopted.

SUBJECT NO. III.

Cereal Rusts and their control.

(For proceedings of the sub-committee on the subject vide Appendix III).

The Chairman invited Rai Bahadur R. L. Sethi, who was the Chairman of the Committee on subject No. III to introduce the subject.

Rai Bahadur Sethi opened the discussion by saying that at the Committee meeting he explained the whole history of the work that was being carried out at present and had been done in the past. The severe epidemic that happened in 1946-47 was known to all. The question of control had been taken by the Government of India particularly as in some provinces the incidence was so severe that there was not enough seed left for the next year and C.P. alone had to import about 40,000 tons of seed for sowing purposes. With this background of severe epidemic the severity of the situation had been taken into consideration by the Government of India and they called two or three meetings to decide what action should be taken in the matter. It was decided that a high-level committee should be constituted and named as Wheat Rust Control Committee with D.R. Sethi, Agricultural Development Commissioner, Dr. J. N. Mukherjee, Director, Indian Agrl. Research Institute, Dr. Pruthi, the Plant Protection Adviser and the Agricultural Commissioner with the Govt. of India as members, the last-named being made the convener. They called a meeting of this committee at Delhi and they invited the Plant Pathologists and Mycologists of some provinces who participated in the deliberations. The recommendations of that committee had already been circulated. The Committee on Wheat Rust Control recommended to the Government that Dr. Mehta's scheme for suspension of summer wheat cultivation in the Nilgiris and Palni hills in the Madras Presidency and in the Hassan and other districts in Mysore and Dharwar and Belgaum districts in the Bombay Province should be approved and summer wheat cultivation in those areas should be stopped by Legislation. The Government of India had already been approached to sanction the scheme as soon as possible. It was acknowledged by all that the final solution of the problem was to evolve a rust-resistance variety. Until this was discovered it was necessary to do work of other types also. It was necessary to see how far Dr. Mehta's scheme could be effected. In the meanwhile the Government of India had been approached to take action on the recommendation regarding the stoppage of cultivation of summer-wheat that formed the focus of the infection. There were some Mycologists, particularly the Madras Mycologist Dr. Thomas, who said that the remedy had already been tried for 2 years but it did not give good results. Dr. Mehta pointed out that the work was not effectively supervised and cultivator did not put their heart into the work because the compensation that was promised to them had not been given. It was considered desirable that the Central Govt's Rust Control Committee should be closely associated with the work to be done under Dr. Mehta's scheme, if it was sanctioned by Government. In the Committee meeting, Mr. Ekbote had said that the work on physiologic [illegible] of rust was very important in view of the fact that two new [illegible]

stem rust had appeared in C. P. during the last six years and two biotypes in Mahabaleshwar. He said that this indicates the possibility that more races might arise later and he was, therefore, of the opinion that work on this aspect of the rust problem should be intensified. So far, in India, they had touched a fringe of this problem. In western Canada alone, over two million dollars had been spent on the breeding of rust-resistant wheats. Compared to it India had so far spent very little.

Mr. Kulkarni, Mycologist, Gwalior, referred to the rust nurseries recommended by the Wheat Rust Control Committee and wished to know whether the work would be confined to the 5 zones as had been recommended or whether it would be carried out in the plains also where growing of wheat was of importance.

Mr. Sethi said that the Wheat Rust Control Committee had recommended that the intensification of this work should take place at 5 centres and the whole country should be split up into 5 zones, viz.,

A. Bombay, Hyderabad.

B. C. P., Bhopal.

C. East Punjab and U. P.

D. Bihar, West Bengal, Orissa,

E. Mysore, Travancore.

Mr. Varudarajan from Madras, who was present in the committee referred to the same point which was raised by Mr. Thomas. It was stated that Dr. Mehta's work had been tried already but without any success and so if the work was to be continued, it should be done strictly under the control of Dr. Mehta and not under that of the Provincial Governments. The Committee however did not agree with this view. At the meeting Rai Bahadur Kalidas Sawhney made a very good suggestion. He pointed out that although work was being carried out for a very long time and varieties had been imported from Russia and various other places by the botanists and other physiologists and crossings had been carried, they were not aware as to what material was available for intensifying the breeding work. He suggested, therefore, that a small expedition should be sent abroad to collect the material which might be of great use for the purpose. The Committee endorsed this view. After taking into consideration the points made the Committee made recommendations under three categories, viz.,

1. Fundamental Research,
2. Control, and
3. Agronomic work.

Under Fundamental research, the Committee recommended that intensive work on physiological races, their origin etc., should be carried out. The second was that the rusts of millets like sorghum bajra, seteria should be further investigated ; their life histories studied and damage they cause ascertained. Without data nothing could be done and data should be collected in order, that necessary action might be taken. In respect of control, there were four recommendations. The first was made

by Dr. Mehta for suspension of summer cultivation of wheat in certain places in India. It was desired that Dr. Mehta should be closely associated with the work. The second was that dusting of sulphur should be resorted to as a means to check this rust and that certain other fungicides should also be tried. The third was the provision of 200 dusting machines for the use of provinces and states and 20|30 tons of sulphur to be made available in the important wheat growing centres so that action might be taken at once. The fourth was that work on breeding should be intensified funds allotted for this purpose. The work should be entrusted to breeders specially appointed for this purpose. In the same connection it had been suggested that breeding work should be conducted not only in the five zones but in as many areas of provinces as possible and help should be given by the Centre. The committee recommended that an expedition consisting of two or three wheat investigators should be sent abroad immediately to collect materials which would be resistant to rusts and other fungus diseases and which might be useful for genetic purposes. The committee further recommended that, in order to take prophylactic measures in time, weekly data on temperatures, rainfall and humidity should be collected to see what the conditions were under which the rust appeared and to safeguard the crop in time if any measure could be taken up. It was further recommended that the assessment of losses due to wheat rust should be determined in all wheat growing regions. Although Dr. Mehta had said that there were no alternate and collateral hosts, Mr. Thomas and Mr. Vasudava noted in their report that there were one or two hosts in the South that were likely to form as alternate hosts. It was also recommended that *Beriberis Asiatica*, found near Pachmari in C. P., might be tested for such purpose. The Committee recommended that assessment of damage should be studied thoroughly. While considering the recommendations made by the Director, Indian Agricultural Research Institute the Committee was further of the opinion that mixed cropping was not likely to give good results, and although the wheat Rust Control Committee accepted that recommendation, the members of this committee, as a result of the discussions, felt that mixed cropping was not likely to be fruitful but that early maturing and semi-resistant varieties might lead to the desired ends. For this purpose more attention should be paid to the breeding of semi-resistant varieties. Finally, the Committee noted with satisfaction the work carried out by Dr. B. P. Pal on inter-specific and inter-genetic crosses. Although the work had not yet led to success the attempt was praise-worthy and the committee recommended that the work should be pursued further.

Dr. J. N. Mukherjee: said that the position was that certain statesmen had aproached the Hon'ble Dr. Rajendra Prasad, who was the then Minister for Agriculture and Food, pointing out that something should be done to control this rust. At the instance of Dr. Rajendra Prasad the Indian Agricultural Research Institute took up task of preparing a review of what was known about rust and the method of its control, in India and abroad. That review had been published in 'Science and Culture'. Dr. Mukherjee took this opportunity of thanking Dr. Pal for the amount of labour he and his staff had put in this connection. At the conference over which Dr. Rajendra Prasad presided certain provincial Mycologists, were of the opinion that a survey was necessary in

order to find out whether there were alternative hosts or not. The work that had been done so far was not comprehensive. Since then the little work that had been done, as well as the reference that had been made by this committee suggested that there were alternative hosts which could not be ignored. The main point of Dr. Mehta's suggestion was that if the measures recommended by him were adopted this wheat rust would be eradicated. They were all grateful to Dr. Mehta for the pioneering work he had done especially in relation to the physiological part of the rust problem. The provincial Mycologists present at the conference definitely expressed the opinion, however, that they had reasonable doubt as to whether this method would succeed. Ultimately they agreed that a trial should be conducted to test Dr. Mehta's suggestion. The recommendations of the present committee should be considered in the light of these provious discussions. It was not considered to be a very important solution of the problem but it was agreed that Dr. Mehta's scheme was worth a further trial. Secondly about control with fungicides, *e.g.*, sulphur the question was one of organisation and the cost of operation. It was necessary that this question should be gone into very carefully. As regards an expedition for the collection of materials, the Indian Agricultural Research Institute had been in touch with prominent wheat breeders in foreign countries like U.S.A., Russia, Australia and Canada and it had made very good collections. The Institute possessed all that was necessary, to know about the various methods of resistance to rusts that were being used elsewhere. The main trouble was that although breeding against rust resistance was the main solution and success had been achieved on that basis by different countries, unknown races cropped up as a result of which a variety that was found to be very resistant to one kind of rust might be later wiped out by a new race. The remedy lay in continuous effort to breed wheat resistant to the prevailing rusts and the rusts which might appear. It was also necessary to recognise that in India there was not one group of rust, but all the three namely, yellow, brown and black—and to breed wheat against the different physiological races for resistance was a tremendous problem. But the results obtained in the Indian Agricultural Research Institute had already yielded some wheats which were resistant to all these rusts. The suggestion regarding an expedition and collection of wheat material was very welcome. But quite a lot about wheat in other countries was already known. He did not know whether Rai Bahadur Kalidas Sawhney had really in view a plant expedition or merely the deputations of a group of two or three botanists to collect information from the various centres of the world. The two propositions were quite different. The plant expedition which had to be worked out properly, especially in unknown regions required a great amount of preliminary work. They discussed this question at the Royal Society Empire Scientific Conference and also in the review of the Imperial Agricultural Bureau Conference, and all the prominent botanists who were present emphasised that international co-ordination could be effected and that there should be a proper organisation to do all this. In fact, specific resolutions were adopted in that conference.

Dr. Mukherjee added that it appeared to him that the Committee did not properly appreciate the intention underlying the suggestion regarding mixed cropping. He saw in Bhopal that by mixed cropping with gram and wheat, the peasants could get at least gram if wheat failed. While in general agreement with the recommendations of the committee, therefore, he was of the opinion that firstly a detailed survey was still necessary to find out the alternative hosts. Secondly, before they embarked upon trials of sulphur they should take into account the cost involved. Thirdly, they should not ignore the suggestion regarding mixed cropping. Fourthly, the only solution lay in extensive breeding against and study of wheat rust. It was not true that breeding against rust resistance had been successful. In fact, it was claimed by those people who were in the know all over the world that this had been the most successful method.

Dr. Pal, Head of the Division of Botany, Indian Agricultural Research Institute, said that he was in agreement with the Agricultural Commissioner on many points but there were a few points on which he differed from him. At the meeting of the Wheat Rust Control Committee, a larger number of Mycologists and Plant Breeders were present and almost without exception they were against putting the clean up scheme into operation because they felt that it could not give the desired results. The matter was again thoroughly thrashed out by the Botany Committee of the Advisory Board of the Indian Council of Agricultural Research and the Committee which had four Mycologists on it, was unanimous in the opinion that this scheme should not be financed. Another important matter was that results could not be expected within a short period of time. It had been stated that if a scheme was financed just for one year, it would be possible to know once for all whether it would be a success or not. This ignored the fact that severe rust epidemics did not occur every year. If the rust epidemic did not come at a place in the first year, the second year or the third year, it did not mean that it would not in the fourth year also. It might not, therefore, be possible to draw any conclusion unless the scheme was carried out over a long period of time. Dr. Mukherjee had drawn attention to some of the aspects, particularly the one about alternate and collateral hosts and he found that the Committee themselves, under their agronomic recommendations had pointed out that the work on alternate and collateral hosts needed further investigation as also the precise method of dissemination of rust. The Agricultural Commissioner himself referred to a rapid survey which was carried out a few months back which disclosed the fact that there were some grasses which acted as alternate or collateral hosts of rust, although the survey was carried out very rapidly and over a small portion of the country. If that was the position, and in view of the fact that the Mycologists and other Botanists had definitely expressed their opinion against the scheme the Board should be very careful to decide whether a recommendation of this kind should be made or not. Another point related to the question of the use of sulphur to save the seed crop in certain areas. It had been suggested in Dr. Mundkur's note that if they could save the seed crop then they would be saving something for the country. He pointed out in his note that

the C.P. had to import about 40,000 tons of wheat last year. Dr. Vasudeva, who was in-charge of the Mycological Division of the Indian Agricultural Research Institute had worked out the cost and according to his calculations, the cost of sulphur spraying would come to Rs. 13,28 millions of rupees in a year whereas the cost of the crop itself would be about Rs. 11 millions. He had not, however, taken into account the cost of the machinery of which they would require a large number. He also pointed out that in Canada sulphur dusting was given up in 1934 on account of its high cost and the authorities there now recommended its use only for the experimentalists and grain exhibiters. The other point to which he wished to refer was the first recommendation regarding more work that should be done on physiologic races, their origin, etc. They were not probably justified in criticising Dr. Mehta's statement that the number of rusts in this country was comparatively lower. If they compared the numbers they had with that of other countries they would find the number of races small.

Regarding breeding rust-resistant varieties, the work was time-consuming, arduous and difficult but the great rust authority in the U.S.A. It was true that some varieties were known to lose resistance because new races of rust cropped up but, on the other hand, there were other varieties which remained resistant. It was also true that some varieties lost their resistance due to environmental conditions and temperature. There were again other varieties which maintained their resistance under those conditions. Therefore, as in other countries, they should be watchful and go on doing breeding work.

Rai Bahadur Kalidas Sawhney, said that Rai Bahadur Sethi had explained in detail the recommendations made and the observations recorded by the various members of the Committee. The remarks of Dr. Mukherjee and Dr Pal, appeared to him to lay a greater emphasis on one or other recommendation of the Committee. He felt that the Agricultural Commissioner would be too glad to modify some of the recommendations to the extent that the special emphasis laid by the previous two speakers on some of the points, might be brought out more forcefully. Personally he had no objection to take course.

Regarding the point made by Dr. Mukherjee about a plant expedition, the object was that the expedition should visit areas where wild wheat was grown and also pay a visit to the various experimental stations where breeding for rust resistance was in progress. Every plant breeder has in his collection a large quantity of useful breeding material which he might never have mentioned in his annual or progress reports. It was by a visit to these important breeding stations, actually contacting the breeders, and seeing what material they had that they would be able to collect many more varieties or strains, which although they might not have been of great use to the plant breeder in question, might still be of use to India either in the breeding of rust resistant types or even in connection with other genetical problems.

In regard to the point raised by Dr. Mukherjee about mixed cropping, the Sub-Committee was given to understand that mixed cropping was being advocated for reducing the evil of rust. Everyone in the

Sub-Committee had expressed the opinion that whether it was a pure crop of wheat or it was grown, mixed with crops like gram, saf-flower or other crops, the incidence of attack on the wheat crop in a year when rust appeared as an epidemic was more or less similar. It was, therefore from that point of view that the committee expressed the opinion that mixed cropping as a means of reducing losses of rust on wheat was really not a satisfactory solution. No one doubted the statement made by Dr. Mukherjee that mixed cropping served as an insurance against complete loss to the cultivators. As regards the details of the alternate hosts, the study of the part played by them should be continued and intensified. At the same time, the study of physiologic races should also be made more intensive. With regard to the trials of sulphur, the Sub-Committee's idea in making the recommendation was not that sulphur was a really effective means of controlling rust but it made the suggestion more with a view to study the possibilities of the use of sulphur as well as other fungicides as likely means of control. The Committee had also definitely in view the working out of the costs of this method, whether as a prophylactic measure or as a control measure. As a control measure the Committee doubted very much that sulphur would really be an effective method of checking the damage once the rust appeared in a very severe form. The question of summer wheat was discussed in detail and the view was held, as had been pointed out by Dr. Pal, that an experiment carried out for one year alone was not likely to give any definite results.

Dr. Mundkur, Deputy Plant Protection Adviser said that the survey which he carried out in Travancore and Orissa did not have any relation to collateral or alternate hosts. It was just to determine the extent of some of the wheat cultivation in these two provinces. In Orissa he was told that in some of the hill tracts in the province there was a good deal of cultivation of summer wheat. They went there and found that that was not true at all and there was no summer wheat cultivation. The second place was Travancore. They found that they grew about 50 to 60 or 100 acres of wheat in summer. The second point was about sulphur dusting. He knew that it might cost more than Rs. 22 millions to dust all the wheat seed that was required, say, for C.P., in making the recommendation they said that each province should have in reserve only 200 dusting machines, each costing Rs. 110 and 20 to 30 tons of sulphur. He had the testimony of Rai Bahadur Sawhney, that in 1946-47 he was able to save his crop of wheat by giving one or two sulphur dusting and thus save all his valuable seed for distribution.

The third recommendation which this committee made was that they must have in reserve machines for dusting sulphur because there was a frantic appeal from Ajmer-Merwara, saying that the rust there was very bad and something should be done at the earliest moment. They could not do anything as there was no sulphur in reserve and no dusting machines. It was just to get over a situation like that that this particular recommendation was made.

Mr. Chavan said that in Bombay they had to do sulphur dusting not only once or twice but 4 to 5 times. In some places they did 5 to 6

dustings at the interval of 5 to 6 days. The cost was rather prohibitive. It came to Rs. 20 to 25 per acre. The crop was not fully saved but only about 50 to 60 per cent. was saved. But this was with regard to the breeding material and the nucleur material, because they had certain schemes and the nucleus schemes had to supply the original seed for further multiplication and this was saved by sulphur dusting. His suggestion was that the agronomical work should be done in collaboration with the Agricultural Meteorologist. He had set up a laboratory at Niphad and had been recording data in connection with crops weather co-relation. This type of work might be coordinated by setting up fully equipped meteorological laboratories at important centres where this rust work was going to be undertaken.

Dr. Bal said that regarding agronomical work and correlation of climatic data, there were no two opinions that such a thing was very essential. He did not, however, think that it was easy to predict the type of climate one was going to have after sowing the wheat. He was informed during 1946-47 by some cultivators in Central India that such a severe rust attack had not been recorded for the past 20-25 years. It was a completely wet season from the time of sowing to the end of March with slight variations towards the end. He did not think it was easy to predict whether the early or the late variety was going to escape rust because nobody could say what was going to be the subsequent climate. For example, in 1946-47, the experience at the Indore Institute has shown that late sown variety not necessarily the long duration one, but the same variety sown late, had escaped the attack of rust to the extent of 70-80 per cent. whereas the same when sown early had been attacked practically to the extent of 80 per cent. He, therefore, felt that it was better to introduce at least two dates of sowing with an interval of about 10-12 days, depending on the season.

In regard to growing summer varieties in the hills it was mentioned that although the rust epidemic did not come every year, but once in three years or so, normally in the plains every year there was certain amount of rust in wheat, though not in an epidemic form.

As regards mixed cropping, Dr. Mukherjee clarified the recommendation *viz.* that mixed cropping was not to be considered as a system to prevent the rust but to save at least some part of the crop. In this connection his suggestion was the growing of early varieties of wheat either of varieties of two durations or trying one of the same varieties with two different dates of sowing should be done in order to guard against the hazards of climate.

Mr. Ekbote said that Mr. Mehta himself was not sure that the summer wheat crop itself was the only source of infection. He (Dr. Mehta) did not rule out the possibility of any other focus present in C.P. or in Bombay. Nor did he dispute the possibility of the collateral hosts acting as secondary source of infection. So in view of this fact he doubted whether this measure of control of rust would be worthwhile undertaking. Similar attempt was made in the years 1943-44 and 1944-45 and both these years they had heavy incidence of rust in C.P. and they had forwarded samples of rust to Dr. Mehta.

With regard to the recommendation of the sub-committee advocating the use of early maturing varieties, their experience has been that in 1943-44, when the wheat crop was very greatly affected and when the Government had appointed him to survey the damage, I. P. 52 wheat which is relatively very early maturing, escaped the damage to a very considerable extent. As a result of this observation the Government had initiated a seed distribution scheme for distributing pure seed of I. P. 52. Their experience was that generally in the north of the province, where late maturing varieties are grown, the infection of rust came later than on the southern side bordering the Bombay Deccan and the Hyderabad. That was why he suggested that early maturing varieties like I.P. 52 and other similar varieties should be grown. It might also happen that late maturing varieties may escape the damage if rust infection were to occur earlier in the season and its further development checked later on due to weather conditions becoming less favourable for its progress. The recommendation made above has to be taken in the light of the general experience. As regards early maturing varieties being found less susceptible at Indore he said that experiments carried out by him for 4 years with replicated trials with three dates of sowing showed that the early sowing was always associated with the least damage of rust.

Mr. Jacob (Madras) said that as regards the proposed expedition it was absolutely necessary to get material by workers themselves. The difficulty was that they did not get right material.

Mr. Chavan said that in Bombay their experience was that early varieties generally escaped rust. Jay variety which had been evolved from triple crops between Dicoctum and Durum Vulgare had given the same experience. The early type which matured within 120 days had given the same experience. Early type was more vulnerable to paddy rust.

Mr. Kulkarni said that with early varieties of wheat they conducted experiments in Gwalior for the last 3 or 4 seasons and last year when the epidemic was very severe they had collected rust resistant varieties from the Central station, Delhi, Bombay and Indore and also their local varieties and in all these they found that early varieties did escape the disease to a certain extent as compared to the late varieties and in his report he had given all those varieties which were found to be really useful, *viz.* IP 111, IP 52 and some of IP 80|5. Of course it was not a remedy for those tracts where durum wheats were prevalent. In those areas these varieties to a certain extent would mitigate the situation. One must try to breed one's own durum wheats suitable to the tract and having qualities of yield and rust resistance. The appearance of rust was observed for the first time as early as in November. He made a reference to Dr. Mehta inquiring as to how the disease came in. If it came from the sub-montane areas of Himalayas there was no rust at that time which came all the way over and leaving aside all the Central Indian States. It should have come from the Nilgiris but there were no disease in Khandesh at that time

Rai Bahadur Kalidas Sawhney said that a suggestion had been made by Dr. Pal that in the agronomic recommendations made under the

agronomic work in recommendation No. 3, it should be suggested that cultivators should sow their crop on two sowing dates. In the greater part of the country where wheat was grown under rain-fed conditions, this suggestion was not practicable. Two dates of sowing might be adopted in areas where irrigation water was available. But there also it would depend upon irrigation authorities whether they would make water available for two different periods of sowing when they had their own rotation for the distribution of water. The second point that was suggested by Dr. Pal was about the study of records of humidity, rain-fall, temperature etc., in order to see what co-relation there was between the incidence of rust on the wheat crop and the various factors constituting this. It was precisely with that object in view that the study of past records and also of records of the future had been suggested. For instance, it was known that in 1946-47 in some parts of the country there was a continuous hot weather in December, January or February and in other parts it was late, rains in the month of November accompanied by a virtual absence of cold weather. These conditions proved very favourable for the appearance of a heavy attack of rust. Now if by the study of such factors of rain-fall or minimum temperature or humidity from past records they could establish a high correlation between them then it would be of great advantage.

Dr. Mukerjee said that the Board would perhaps like to know the results obtained with rust affected wheat seeds. Samples were collected from many centres all over the country and their capacity for germination and growth were recorded and it was found in a large majority of cases that the wheat did germinate well and ultimately matured fairly well. Except in some cases they did quite well as compared with normal wheat.

The chairman said that the matter was really important. He was glad, that with minor changes here and there, all the scientists had agreed that it was of the utmost importance that they should do every thing to control rust and to produce rust-resistant varieties of wheat. He felt sorry that Dr. Mehta had again came in for criticism. He did not hold any brief for him but as one associated with the Indian Council of Agricultural Research since its inception, he knew that Dr. Mehta had been doing this work for a very long time. It was true that he had not achieved all that was expected of him nor that his methods had been accepted as perfect but it could not be said that no further investigations were required. Dr. Pal and Mr. Ekbote were present at the Rust Control Committee when this question was thoroughly discussed there and he was rather surprised that they did not raise the point in that Committee that the proposed method should not be tried. He understood that at the Committee only Dr Vasudeva and Mr. Thomas were opposed to the proposal. He would like to clarify that this committee had only repeated the recommendations of wheat Rust Control Committee, and after some discussion the Committee decided to look into the great damage caused to the wheat crop by rust and the extreme urgency of taking some immediate steps to escape from this menace. The scheme of control measures as advocated by Dr. Mehta to be adopted for three years was a trial measure and the work should be reviewed annually to assess the value of the experiment. Simultaneously other measures had to be

adopted such as, banning of summer cultivation of wheat, erection of research laboratories etc. In his opinion Dr. Mehta might be asked to put up details of the proposals showing the staff and other facilities required for carrying on the work for three years.

Members were aware of the colossal damage that the rust was causing and the continuance of work done by Dr. Mehta had been recommended by the Wheat Rust Control Committee as well as by this Committee. They might or might not agree with the worker put in a broader sense and in the interest of the country they should agree that there should be a fair trial. After all, this control was going to be taken up only in the peninsular India and not in other places. He thought that the Board might agree with the recommendations of the Wheat Rust Control Committee.

With regard to the work on inter-genetic and inter-specific crosses, it was expected that this would be taken up in collaboration with the Meteriologist and he hoped that the Board would agree to this:

Regarding the plan of dusting with sulphur it was agreed that it was very expensive and could not be taken up on a very wide scale but as was suggested, to save the nucleus seed, it might be tried.

Rai Bahadur R. L. Sethi said by way of clarification that at the Wheat Rust Control Committee both Dr. Pal and Mr. Ekbote did raise objection, but ultimately, the Chairman said that it was a trial measure in the absence of any other remedy. The Government of India said that they were purchasing grain worth crores of rupees every year, and that something must be done to prevent this waste. They thought, therefore, that Dr. Mehta's remedy was something at hand which might be taken up immediately and the committee decided to try it although objections were raised by several gentlemen. Ultimately they agreed, with the exception of Dr. Vasudeva and Mr. Thomas who remained absolutely adamant. The rest in spite of the objections, agreed to give a trial to the recommendations.

The Chairman then placed the recommendations of Sub-Committee before the house. The following resolutions were then adopted:—

"1. *Fundamental Research.*

(i) The Committee desired that intensive work on physiologic races, their origin etc. should be done. It did not feel justified in the statement made in one of the papers that there were and would be only a few races of rust in India as that was not borne out by facts. The appearance of three new races in C. P. (34, A, B) and two in Mahableshwar (42, A B Bio-types) in the course of a few years indicated that there may be more races already existing or would arise by mutation or other means.

(ii) The rusts of millets like sorghum, *bajra* and *setaria* should also be investigated.

2. *Control.*

(i) The scheme for suspending wheat cultivation in summer in parts of Peninsular India as recommended by Dr. Mehta and approved by the Wheat Rust Control Committee should be sanctioned and Dr. Mehta should be closely associated with work to ensure that it is carried out to his satisfaction,

(ii) The plan of dusting sulphur as a fungicide against wheat rust should not only be carried out but similar other fungicides should also be tested.

(iii) The Committee endorsed the proposal made by Dr. Mundkur in his paper that in each province and State there should be at least 200 dusting machines and 20 to 30 tons of sulphur dust in reserve for use against rust wherever epidemics are apprehended in order to save at least some wheat for seed purposes.

(iv) The Committee recommended that work on breeding should be intensified and more funds should be placed at the disposal of the Provincial and State Governments in order to do this work in a more efficient and intensive manner and to meet breeding stations to meet the requirements of different wheat growing provinces and States should be opened and placed in charge of breeders specially appointed for this purpose. Large sums have been spent, *e.g.*, by other countries in this work, *e.g.*, Canada spent two million dollars alone in its Western tract for such investigation over a period of 28 years.

(v) The Committee recommended that a deputation consisting of two or three Wheat Investigators should be sent abroad for the collection of wheats resistant to rusts and other fungus diseases and other material which may be full for genetic purposes.

3. *Agronomic work.*

(i) The Committee agreed that in order to take prophylactic measures in time, weekly records of temperature, rainfall and humidity should be maintained and the data co-related with rust incidence and wheat yields in as many places as possible in the wheat growing regions. Past data, wherever available, may also be corrected and analysed.

(ii) Assessment of losses due to wheat rust should be determined in all wheat growing regions. The work on alternature and collateral hosts needed further investigation as also the precise methods of dissemination of rust. The variety *Beri beri assiatica* which has not been tested for its susceptibility to wheat rust should be tested by Dr. Mehta and the Indian Agricultural Research Institute.

(iii) The Committee was not hopeful of success of mixed croppings but agreed that the cultivation of early and semi-resistance varieties should be encouraged as that would help in reducing losses by rust.

(iv) The Committee noted with satisfaction the work on inter-generic and inter-specific crosses that is being carried out at the Indian Agricultural Research Institute. Although the varieties of desired qualifications which are resistant to all the 3 rusts together have not been evolved yet the attempts made are worthy of commendation and the Committee felt that the work should be continued with a view to explore the further possibility of evolving complete resistance varieties".

SUBJECT No. IV.

"Review of the comparative merits of different methods of improved farming practised in the country such as co-operative farming, collective farming, consolidated farming, joint management, consolidated holdings, etc., with particular reference to improvement in the yield of crops and economic condition of cultivator".

The Chairman invited Mr. Maclean the Chairman of the committee to introduce its report.*

Mr. Maclean said that the Committee desired to reiterate that Indian Agriculture suffered from having too many men with inefficient implements working for too few days in a year and cultivating for too many fields to produce too small an amount of crop from the land. Having itemised the defects in that way, one of the subjects to be taken up immediately was the question of too many people. In another words, the Committee felt that one of the matters that should be dealt with immediately was the consolidation of holdings. He did not want to dilate on the evils of sub-division and fragmentation because they were all too well known. His Committee felt that in the past, Government paid far too fastidious concern to the ryot for his own ancestral plots with the result that nothing could be done in the way of consolidation. He used the word "Fastidious" quite advisedly, because, once consolidation began as they were informed by the Director of Agriculture of the Central Provinces, the ryot himself, would come forward and ask for his lands to be consolidated.

In the opinion of the Committee legislation should be enacted to make consolidation compulsory throughout the length and breadth of India. It was a difficult matter but the remedy was not to be left with the peasant but with the Government. To leave this to voluntary efforts would bring no results. The Committee further felt that before anything could be done to raise the standard of living, which was the aim, it was necessary to remove from the soil some of the population at present living on it. It was a matter of satisfaction that the industrial policy of the Government of India to step up industrial progress had been so well received by the industrial magnates in the country. Unless industrialisation was stepped up to increase the wealth of the country and to absorb the surplus rural population, there could not be any rise in the present standard of living. Apart from the question of large scale industries the Committee felt that there was a number of industries which were suitable to village and cottage industries should be developed at the same time, and again this was a matter included in the note issued by the Government of India, the other day in which both industry and agriculture were mixed up and it was encouraging to see the forward policy now being adopted by the Government of India. But even if the surplus people were taken away there would still be the same amount of land, lack of capital, inefficient implements and so on. Attempts had been made over and over again to improve this. There had been joint farms, co-operative farms, joint stock company farms (as in Sudan) and all manner of co-operative enterprises but it was not known as to which was the best system to be tried. That was briefly the background against which the

*For proceedings of the Sub-Committee on this subject *vide* Appendix IV.

Committee considered this subject and framed their five resolutions. In the discussion at the Committee it became apparent that people had different ideas regarding the exact connotation of different terms used in various kinds of co-operative farming. It was time that these terms were clearly and unequivocally defined by the Government of India itself so that in future there might be no room for confusion about these terms.

Mr. Patnaik (from Orissa) said that the Committee was expected to make some definite suggestions regarding co-operative farming or collective farming. As far as he was aware co-operative farming meant the same farming practice as was adopted in Palestine by the Jews and collective farming was the practice adopted in U.S.S.R. According to a report the latter kind of farming did not prove quite successful. The conditions prevailing in India were quite different as it was full of a number of landless agriculturer labourers. If in industry the labourer could be given a share, why should not a landless labourer should be given a share in agriculture. He felt that for 20 years to come, it would not be possible to mechanise agriculture in India even with their best endeavours. There were neither machinery nor could they produce or procure them from abroad. It was for them to think how to interest or how to give incentive to the agricultural labourer. That was why he felt that co-operative farming should be definitely attempted in this country. It was suggested some times that the landlord should take some interest in the land and employ capital but this was not likely. Some said that they wanted to use tractors and other mechanical devices but that would keep the landless labourer unemployed. The Director of Agriculture of his province had suggested a scheme of agricultural insurance. He might be asked to explain the scheme to the House. He thought that with the aid of an insurance scheme Co-operative movement might be successful. If the Government of India were to appoint some officer to go round the provinces it might take two or three years before he would submit his report. But the problem at present was very acute. We know that people were leaving agriculture and taking up industry. The agricultural condition in the country was pathetic while thinking of cooperative farming they should think how the agricultural prices also should be fixed otherwise the labourer and the agriculturist would be nowhere. There had been a suggestion for the consolidation of holdings. Almost all the provincial governments had taken it up. They appointed Land Tenure Committees and questionnaires were issued by the All India Congress Committee. He felt proud to say that the questionnaire issued by his Provincial Government had been accepted almost *in toto*. Almost all the provinces had taken up the question of consolidation of holdings and it was no use recommending this as it already had been stressed. From the literature and reports available he was sure that co-operative farming would be very helpful.

Dr. Reheja said that the committee had passed five resolutions and the main theme of these resolutions was that the matter should be reinvestigated with regard to various systems of farming. The Government had been sending out delegation after delegation to various countries to find out the state of affairs there. Dr. Shirname was sent out along with a big delegation to Palestine to study the nature of co-operative farming

there, *i.e.* to study the advantages of co-operative farming and whether it could be adopted in this country or not. In his report he mentioned that the Jewish Agency along with other colonization organizations were supporting co-operative farming by financing it to the extent of 65 per cent from the fund provided from America. India could not go so far as to provide such funds. Besides there were international authorities like Dr. Ruston and socialist leaders like Mr. Masani and others, who have tried to examine this problem in a very dispassionate manner. There was another international authority Mr. Clarke, who examined this problem and came to the conclusion that on the basis of the economics of the cultivation from the point of the fertility of land and from the point of view of the efficiency of production and also from the point of view of the total production in a country it was peasant proprietorship which was the most productive of all systems of farming. The great advantage of peasant proprietorship was that a large surplus of the population was straightaway absorbed in the industry. In the first part of resolution it was stated that the experiment should be undertaken. If this was done it would take at least 10 years before the report of this experiment would be out. In the second part of the resolution it was stated that these terms should be defined. He thought that the experiments were completed in other countries and were condemned from various angles. In his note he had shown that the production rate in countries practising peasant proprietorship had far gone ahead than it was in Russia from the point of view of total production. In the 4th recommendation it was stated that since the Land Tenure System was the biggest obstacle, the Government should take up this work immediately. As far as he was aware, Government had already laid down its Land Tenure policy and were pursuing at vigorously and it was for the Board to make direct recommendation that they should do away with the system. It would cut down exploitation once the consolidation of holdings had taken place.

Dr. T. G. Shirname, Agricultural Marketing Adviser to the Govt. of India said that the Committee had discussed the exact scope of the different types of Co-operative and collective farms operating in various countries like Palestine and Russia and various provinces and States in the country, but could not come to a decision as to what exactly was covered by terms like, collective farming, co-operative farming, joining management, consolidated farming, etc. For instance, in different parts of India the term "joint farming society" was used to convey different meanings. In some provinces even societies organised for the procurement of credit for the purchase of seed or implements or animals were called joint farming societies. In some other areas, societies were formed of 20, 40 or more landless labourers for the allocation of vacant Government land for cultivation and such societies were given loans for the current agricultural operations and for the purchase of bullocks and implements. Even such societies were termed as co-operative or joint farming societies. There were also instances where members of a co-operative society joined together either for the sowing or harvesting of the crop and such societies went under the name of co-operative farming societies. It was, therefore, very essential to have the exact meaning and scope as to what is meant

by either a co-operative farm or a collective farm or joint stock farm or any other types of co-operation in farming, as for instance, the members of the society performing a particular farm operations jointly. The Committee therefore proposed that a Special Officer should be appointed to go into all these implications and prepare exact definitions of the various terms used in co-operative farming, so that every provincial and State authority would know the exact scope of the different terms. The Officer in consultation with provincial and State authorities would then request the various authorities to classify the different types of co-operative farming societies already existing in the country in the light of accepted definitions for the country as a whole.

As regards the Government of India's Delegation to Palestine, of which Dr. Shirname was the Leader, he explained in brief the different types of co-operative farms as developed in Palestine and said that the Report of the Delegation was published several months ago by the Government of India. Copies of the report were sent to all the provincial Governments with specific recommendations as what should be done. The Delegation had recommended the organisation of a large-scale co-operative farm in each province as a demonstration unit and indicated in broad outline the manner and importance of the organisation of such demonstration unit. He, however, regretted that not a single province had yet prepared any pilot scheme on the basis of that recommendation. The main trouble was that there was no specialised agency in the Government of India to press continuously on the provincial and State Government the economic and social importance of co-operative farming for the country. It was therefore very essential that there should be somebody in charge of this important subject in the Central Government, who should go round and urge upon the Provincial and State Administrations to undertake this work in their respective areas at least on an experimental basis. That was the way in which it would be possible to go ahead and find out the practicability of various types of co-operative farming. He was very glad that in the rehabilitation work undertaken by the East Punjab Government, some efforts were being made in that connection and he would therefore request Sardar Bahadur Lal Singh to acquaint the house as what was being proposed to be done for organising co-operative garden and colonies in the East Punjab.

Dr. Parija referred to the recommendation that there should be development of industries, not only in the industrial areas but in the villages as well and said that the pressure on land was very great and unless it was removed to attempt to introduce cooperative farming would be successful because people attached very much importance and too high a value to land. They had little land and unless this was tackled cooperative farming or joint farming would not be successful. In the unsettled areas where the population was rather small cooperative farming was not unknown. They had a system of cooperative bund and their villagers contributed equally by way of labour and bullock power and then they paid the rent and distributed the produce amongst themselves. But all attempts made in the settled areas failed. This was due to the high value attached to land. Industry was taking away the labourers

by paying high wages and the agricultural labourers shifted from the countryside to the industrial side. The result was that they did not get enough agricultural labourers. In this part of the country the daily wages of the agricultural labourers had once been about -|8|- per day but now the rate was Rs. 1|4|- per diem. Formerly the labourer was engaged on an annual basis and they used to get food and clothing plus 24 rupees a year but now it was impossible to get a man for less than Rs. 120 a year plus food and clothing. To remedy this difficulty he had suggested to his Government that they might introduce the system for insurance as they had in England in the case of industry. They could have a national insurance policy and agricultural labourers might be given an insurance policy so that he might be induced to stay in his village and supply the agricultural labour. The Government were still considering and he did not know how long it would take them to come to a decision. He suggested that there must be coordinated development between industry and agriculture, otherwise agriculture was likely to suffer. Of course, one solution was to introduce a sort of joint farming, as Mr. Maclean has pointed out. They were still not clear about the policy of the Government but there should be some sort of cooperative farming for a number of farmers joining hands for the cultivation of agricultural land so that they could introduce machinery for cultivation.

He also suggested that Government might declare that the debts of all small holders with less than 5 acres of land would be written off This would no doubt mean a lot of money but when crores of rupees were being subsidized for the import of food-grains from abroad, why not take courage and give this concession. This would be an incentive for the poor cultivators to join together and cultivate together and would also help in relieving pressure of population on the land.

The Chairman said that as a member of the Board he would like to offer his own comments. Members might have noticed that he did not preside over any of the Committee's meetings. That was deliberate His idea was that he should learn from the deliberations at the plenary session the views that were held by particular Committees on the subjects under discussion so that he might have an open mind. This was desirable in his opinion as when one presided over a meeting of a Committee one's mind became naturally more or less prejudiced by the decisions of the Committee.

He referred to the suggestion regarding the appointment of a special officer for preparing pilot schemes and doubted whether it would be possible for one officer to do such an enormous job. Dr Shirname said that even the report which was published and circulated to all the provinces and States did not elicit a response. About 8 or 9 years ago the ICAR had suggested that the Provincial Governments should put up mixed farming schemes but not a single province came forward with a scheme. He would therefore like to know from the Chairman of the Committee whether the appointment of one single officer for this kind

of work would help very much and also whether he would, however, be experienced he might be in a position to go and discuss and persuade the provincial Governments to put up such schemes. The other thing was about co-operative, collective and joint farming. With his own experience about co-operative farming he thought the word 'co-operative' was quite enough, to scare anybody. Most of the members might be aware that he had suggested a scheme known as the Delhi Development Scheme. There they were going to take 20 villages in two units. 10 in the irrigated area and 10 in the non-irrigated area. In that connection it was introduced to have a co-operative society in each of these villages and ICAR were to give them all the facilities but not any subsidy. The facilities would consist of improved seed, improved implements at reasonable prices and other things. The intention was to try to improve the implements by Agricultural Engineers and these implements were to be such as might be within the means of the cultivators. It should also be possible for the implements to be manufactured in the villages. The villages had been surveyed and the villages were to be divided into 3 categories *i.e.*, good cultivators, mediocres and bad cultivators. An attempt would be made to find out the reasons for this variation To the very first village taken up he and his staff went with great enthusiasm and advised the villagers to form themselves into a co-operative society. Members would be surprised to know that even in the presence of the collector and other officers everybody refused point-blank. He was not, however, disappointed. These villages were situated about 10 miles away from Delhi and the villagers supplied milk to Delhi through the middle-men. It was intended to take over the milk from the villages and give the villagers slightly better profit than what they were getting at present. The milk was then to be sold to milk sellers or dairy men also at a better profit to the Council which would guarantee the purity of the product. Half of those profits would be given to the villagers and half would be contributed towards their membership. Similarly the scheme intended supplying improved seed or exchanging the inferior seed belonging to the cultivator at the sowing time. Again when the crop was harvested it was to be taken at a little premium after leaving what was wanted for their seed and for themselves. The improved seed thus obtained would then be sold at a higher rate. Similarly he intended giving half of the profits to the cultivator as a bonus and half of that for other improvements. It should not be forgotten that the cultivator was inherently conservative but he was not a man who did not know what he wanted. The only handicap was that he had not the purchasing power. He was very often scared by lectures and schemes. It was necessary to create confidence in him not by mere talks but by giving him what would yield more money and increase his purchasing power. He expected that by this way it would be possible to enlist the co-operation of the cultivators.

Sardar Bahadur Lal Singh said that talk of co-operative farming and joint management farming methods and tenancy improvement in

tenancy system etc. frequently emanated from people who were somewhat visionaries and not in touch with village life and did not understand the psycology of the villagers.

Referring to occupancy tenant system, about which there was a great deal of talk in India, as well as in the East Punjab, he said that wherever this system prevailed the average production was low and he felt that the system was a great curse to all concerned. It did more harm than good. The tenant had little interest in the improvement of the land because of psycological impression that he was not the owner of the land. The landlord had no interest in bringing about any great permanent improvement in the land as he was not to gain financially from such improvement and the country suffered heavily because of low production from such lands. The sooner occupancy tenant system was abolished the better for all. Either a man should be the owner of land or be a tenant at will.

Referring to the co-operative farming, he said he had great faith in co-operation as he had been interested in this work from the early days and had gone Palestine to see this work. He had also seen the working of California Fruit Exchanges in America and other places. Last year in the East Punjab also, in connection with rehabilitation of refugees some gentlemen had advocated, or even insisted on joint management of farms evacuated by Muslims, but the experiment had not proved a success. He felt that even in the case of joint management of co-operative farming, unless there was incentive to work and unless the peasant knew that he was going to get the reward of his labours, he was not going to put in his best efforts. The Punjab Canal Colonies afforded a remarkable instance where pioneer work had been done, by which barren waste lands had been converted into smiling fields by the enterprising Punjabis. People who did it knew that by putting in hard labour, they and their sons would be the owners of land. In recommending co-operative farming or wholesale joint management farming, they were ignoring one important fact, namely perohal initiative or incentive. If the villagers were given a 500 acre of land which they were to own and cultivate jointly and get equal benefits there would be no incentive for individuals to work very hard. At any rate, our villagers are not yet ready for wholesale joint management farming.

Referring to the improvement in agriculture, about which they talked so much in India, *S. B. Lal Singh* said that in spite of all efforts there has been little improvement. The reason for the primitive condition in agriculture, in his opinion, was that agricultural profession had so far remained in the hands of the illiterate, ignorant class of people who have little finances at their disposal and are unable to plan out. Unless and until intelligent and educated class of people with enterprising spirit and necessary capital, take to farming as a business proposition there was little hope of any improvement in agriculture. Advocating "occupancy tenant system" as was being done in and out of season in many provinces in India meant that this profession should

remain the monopoly of only ignorant class of people. It was to be realised that agriculture was a science and required as much intelligence and labour as any other industry.

Referring to the Co-operative Garden colonies scheme, S. B. Lal Singh said that the scheme was devised by him in a way that it combined the blessings of co-operation with the benefit of personal initiative. Co-operation, no doubt, was compulsory but only in certain matters where co-operation was definitely to the advantage of settlers and there was no alternative for them, but to co-operate *i.e.*, production of nursery plants on co-operative basis on the spot. tubewell irrigation, grading, packing and marketing, fruit preservation and Cold storage. but personal incentive was not lost sight of as every settler would own his own piece of orchard and get reward, in accordance with the amount of labour put in by him.

Referring to the necessity of these Garden Colonies. S. B. Lal Singh stated that the partition of the country had brought about to refugees misery and untold sufferings unheard of in history. People who had millions were rendered paupers and those who could give away lakhs in charity are in need of even small amount of money ; the Punjab that used to be the granary of India and a surplus province had in the Indian Union been reduced to East Punjab. a tiny province which has been blend white. All the horticultural achievements of which they were so proud in the undivided Punjab, have been largely left in West Punjab. The Government of East Punjab wanted to develop the fruit industry most economically and in the shortest possible time which was proposed to be achieved by the co-operative Garden Colony Scheme. It was intended to establish 10.000 acres of gardens in selected block of 1,000 acres each in every district of the Province. Each settler was to get 20 acres who would mostly be educated people and preference will be given to those who had special interest in gardening. About 8,000 applications had been received for allotment of land in these garden colonies, and there is great enthusiasm from the public for the scheme. There would be about 50 families in each colony who will form a co-operative society to do most of the work on co-operative basis. The chief defects in the case of existing gardens were that all the plants were not of good varieties, some gardens may yield 500 rupees or even a thousand rupees per acre and others not even a hundred rupees, because of the inferior variety of plants in the latter case. For the success of the proposed scheme. it was necessary to ensure (1) supply of plants of reliable varieties, (2) control of diseases. (3) proper marketing and utilization of every ounce of fruit produced and all these factors have been fully safe-guarded and the scheme is thus a fool-proof. The plants will be produced on the spot which would guarantee the reliability of the varieties and the cost would also be very insignificant. *i.e.*, about 3 to 4 annas a plant as compared with a rupee or more per plant in the market. All this meant reducing the capital cost of planting to a very small amount. Regarding diseases and their control. the

constitution of this Co-operative Society would make it incumbent on the part of the Association to get rid of the disease as soon as it appears.

Regarding Marketing, an individual, owning an area of 20 acres of garden, could not be expected to send his fruit independently to distant places, like Bombay, Madras or Calcutta, but in this case the total aggregate area being 1,000 acres of garden (although owned by 50 persons) stocked with the best varieties of plants, the Colony would be in a position to send its fruit to distant places and they can expect to secure remunerative prices.

Another most important factor was the utilization of waste fruit. Even in the best seasons and in nicely managed gardens, 10 to 20 per cent. of the fruit produced easily went to waste. To utilize this fruit, there would be Fruit Preservation or by-products Factories in each centre in order to see that no fruit was allowed to waste. There was also a proposal to have Cold Storage Plants to enable the settlers to sell their fruits in seasons of scarcity. In addition, certain other industries would also be taken up which are allied to gardens, *i.e.*, Dairy, Bee-Keeping, Poultry, Vegetable Seed Production, etc. He felt sure that these 10,000 acres planted in concentrated areas by modern methods would give more fruit than double the area planted in scattered places.

Mr. S. C. Roy (West Bengal) said that in his opinion the idea of some of the resolutions was quite not definite at all. They ought to be well defined describing the nature and scope. Bengal had been partitioned, and the permanent settlement was going to be abolished and a new system evolved. Therefore it would be very wise to try out what particular system of farming might be most suitable there. Any prevailing dogma should not be countenaced and co-operative, joint stock, or any other kind of farming as may be considered suitable for a particular tract should be tried out on a very large scale. Members might be aware that poet Tagore was doing rural uplift work for over 50 years and although spectacular sucess had been achieved, it was not well known in other parts of the country. He suggested that an account of the work done in that connection might be obtained and knowledge about all improvements or successes achieved elsewhere should be pooled and utilised before proceeding with new projects.

Dr. Shirname said that it appeared to him that the proposed co-operative garden colonies in the East Punjab were exactly on the lines of the small-holders' Co-operative farms described and recommended in the Report of the Indian Delegation on Co-operative Farming in Palestine. There were some minor differences but the principles were the same. He further emphasised that there could not be one set of co-operative farm for all the Provinces and State and even for the different tracts in the same province or state, some variations in the organisation and working of the different types of co-operative farms would be. therefore inevitable to suit the local conditions in regard to men, money, social and economic conditions and the current agricultural practices in a particular locality. As regards the recommendation made

by the Committee for having a separate Officer to deal with the subject for the whole of India, the idea of the Committee was that that officer should actually go to the Provinces and States and in consultation with the local authorities prepare a pilot scheme, something on the lines of co-operative garden colony societies proposed to be set up in the East Punjab.

As regards the use of the word "Co-operative", Dr. Shirname agreed that it had acquired a bad name in some of the country. It was a fact that in several villages the utterance of the mere word 'co-operative' scared the local villagers. He mentioned his own personal experience in some villages in the Bombay Province where it was possible to organise the farmers after great persuation and without using the word co-operative at the various discussions held for the organisation of the society which was ultimately registered as a co-operative society. At the same time, the principle of co-operation had always been appreciated in all villages and if the word 'co-operative' had got a bad name in certain areas, it was entirely due either to bad management or unnecessary scaring people who are already members of co-operative society by emphasising the various penalties and punishments stipulated in the Co-operatives Laws and Rules.

Co-operative Credit Societies just described by S. B. Lal Singh. About the use of the word Co-operative he agreed that this had acquired a bad name. About eight years ago he remembered to have gone to organize a marketing project in the Bombay Presidency and he had with him an officer of the Local Co-operative Department well-known to the people of the place. The very sight of the local officer frightened the people. After a lot of persuation he was able to bring them round and was successful in forming a Co-operative Society which was registered under the Co-operative Societies Act, but the word ' Co-operative ' was not included in the name of the society".

Rai Bahadur Kali Das Sawhney said that the resolutions of the Committee were in five parts and in part 5 it was said that " a comprehensive programme of consolidation is vital to agricultural rehabilitation and that the State should not hesitate to exercise a large measure of compulsion in this sphere and that commensurate with the progress of consolidation there should be development of industries not only in the industrial areas but in the villages as well". He thought that something should also be done to prevent fragmentation.

The Chairman enquired if the idea was that the law of inheritance should be changed ?

R. B. Sawhney said that if that was necessary he would advocate such a change. His idea was that compensation should be given in cash. The question of economic holdings should be considered, depending upon the conditions prevailing and adjustments made. Certain steps had to be taken to prevent fragmentation otherwise they would first be creating the disease and then trying to remedy it.

Rai Bahadur R. L. Sethi said that he did not subscribe to the view regarding the appointment of one officer for going round. There

could be no two opinions about the importance of the subject particularly at the present day when the various Governments were considering the question of the abolition of the Zamindari System and other measures. They should carry out some experimental work in order to find out what type of farming was suitable in a particular locality. They should not run straight away to legislation because stopping of fragmentation and changing the law of inheritance were matters which concerned governments and not the Board directly. Their field of work should be restricted to agricultural activity. They should try to find out as to what results they could get by following different methods of farming in different localities and for that he considered that the best way would be that instead of appointing one officer and asking him to go round, they should appoint a number of officers. The difficulty was that the scheme had not yet been sent to various provinces. They should frame a pilot scheme. The centre had already a large staff. They should be able to frame such a scheme in consultation with Mr. MacLean the President of this Committee who said that a scheme of this nature was already in progress in Baroda. They had already settled aboriginals in different methods of farming and they had carried out some trials of that nature. His proposal was that instead of appointing an officer and sending him round they should frame a pilot scheme at the Centre in consultation with the President of this Committee and then they should send the scheme to various provinces for their views and after having their views the schemes should be reconsidered at the next cold weather meetings of the Scientific Committee and the Advisory Board. If they did so the provinces would naturally take up the recommendation.

Dr. Shirname said that he did not quite agree with Rai Bahadur Sethi's suggestion that the question of fragmentation and consolidation of holdings should be left to itself and that the Board should not dabble with the issue merely because it involved legislation. The question of sub-division and fragmentation of holdings was the one possibly the most discussed not only by those who were interested directly and indirectly in agricultural development of the country but also by all those who had the interest of the country as a whole in their heart. As regards the second point about the preparation of a pilot scheme, he was afraid that there was some misunderstanding about the resolution. The idea was to prepare one model scheme for the country as a whole and then prepare pilot schemes for homogeneous areas in every Province and state with a view to make them practically applicable in that province or State. The model scheme would be decidedly advantageous in that it would indicate lines on which a regional pilot scheme could be prepared. The intention of the Committee was therefore that the Special Officer proposed to be appointed by the Central Government should in the first instance prepare model schemes for the different types of co-operative farming and then in consultation with the Provincial and State Departments of Agriculture and Co-operation prepare pilot schemes of practical applicability for the different provinces and States. For

the preparation of such schemes some centralised agency should be there. It might be an officer of the I.C.A.R. or the Ministry of Agriculture of the Government of India or something else. If that was not considered feasiable, one could hardly expect to see any light or development of co-operative farming in the country.

Mr. Sethi said that one officer might not be acquainted with all the conditions in the provinces.

The Chairman said that the matter had been sufficiently discussed. If consolidation was done, it would again be spoiled by fragmentation in the next generation or so. They could not legislate to prevent this. They could only make recommendation to the Governments who might or might not agree. The question was whether they should take up this question and recommend to the Government of India that something should be done about it.

The other thing was about the appointment of an officer. There were two views—one was that they should ask the Chairman to prepare a pilot scheme and then have it discussed at the next I.C.A.R. meeting and the other was that an officer from the I.C.A.R. or the Ministry of Agriculture or elsewhere should go round and in consultation with the provincial governments prepare schemes which, of course, would be discussed again either by this Board or the I.C.A.R. and then launched, if found to be feasible. The Chairman enquired if the idea was that they should recommend that an officer of the I.C.A.R. or the Ministry of Agriculture should go round or they should ask the Chairman of the Committee to prepare a pilot scheme.

Mr. MacLean, the Chairman of the Committee had informed him, however, that he would n t be able to do this work. His suggestion therefore was that the A.C., the A.M.A. and the Chairman of the Committee might get together and amend the draft resolutions and put them before the Board.

The Board approved of the suggestions.

Mr. MacLean, in presenting the draft of the amended Resolutions said that he did not expect that there would be so much of discussion about this matter. He felt that there was a certain amount of misapprehension which would have to be cleared up. If they read the terms of reference, it would be seen that it included a review of the comparative merits of different methods of improved farming practised in the country such as co-operative farming, collective farming, consolidated farming and so on. If they were going to review the comparative merits of different kinds of farming, they must have data which they did not at present possess. There was no collective farming, no co-operative farming and no joint management at present anywhere in India and so they had no basis for comparison. In ordinary field experiments there was one plot which was compared with another before conclusions were drawn. In this case there were no data from which to draw any observation. It was true that there was a scheme working in Baroda for testing different forms of tenure and management, *viz.*

tenanat farming, peasant proprietorship, co-operative farming and collective farming and the committee felt that that scheme would produce results. In order to get results from other parts of India they had framed these resolutions. They should accept that. Then the resolution would appear entirely in different light. One of the speakers pointed out the merits of co-operative farming in Palestine and another gave the merits of collective farming in Russia. But it did not follow that what was suitable to the Punjab was going to be suitable to Madras and therefore all these different attempts of farming should be tried throughout the different provinces and States.

As desired by the Board, the resolutions have, however, been amended and were for consideration.

The Chairman then placed before the Board the resolutions as amended and adopted. The following were the resolutions :—

"1. That with a view to testing what is the best method of improving the Social and Economic conditions of the cultivators a special officer should be appointed by the Central Government to prepare these schemes.

2. That the officer appointed should do his utmost to see that effect is given to these pilot schemes as quickly as possible by provincial and State authorities.

3. That the officer appointed should describe in collaboration with recognised experts the nature and scope of such systems as, co-operative farming, collective farming, joint farming, joint stock farming and community farming etc. and submit his views to the Government of India for final approval.

4. That in view of the imminent revision in the prevailing land systems in certain parts of India a measure of priority should be given to above proposals.

5. That a comprehensive programme of consolidation is vital to agricultural rehabilitation and that the State should not hesitate to exercise a large measure of compulsion by legislation in this sphere and that commensurate with the progress of consolidation, there should be development of industries, not only in industrial areas but in the villages as well in order to absorb surplus population. It is also recommended that suitable steps be taken by provincial and State Governments to prevent fragmentation of holdings as far as possible".

SUBJECT No. V.

Consequent on the division of the country, to consider measures to be taken, from the short-range and long-range point of view to maximise the production of food particularly of cereals in India, so as to reduce her dependence on imports to the maximum extent possible, and to suggest five-year targets of increase in such production for each administration comprising India.

Mr. M. S. Sivaraman, I.C.S., Director of Agriculture, Madras who was the Chairman of the Committee said that the subject of food production was of pressing importance but the food problem was not a temporary off shot of the war aggravated by the partition of the country. Increasing population without a corresponding increase in food production was a disquieting feature in the economic horizon of the country for some decades. Under-nutrition among the low income groups and malnutrition among most others had been a chronic feature. The remedy lay in the reorientation of the national agricultural, industrial and economic policies so as to ensure a rapid advance in agricultural production and a simultaneous increase in the purchasing power of the masses to enable them to afford the necessary energy-giving and protective foods at a price level which would foster agriculture as a competitive occupation.

Protective foods like egg, milk, meat are luxury articles of agriculture which require at least 4 times the area necessary for raising cereals giving the same amount of energy. As the area of profitable cultivation was limited in the country any general improvement in the nutritional standards could not be brought about unless more was produced from the cultivated lands than is being done at present. Intensive cultivation was therefore a necessary prelude to diversification.

The problem of increasing agricultural production could not be solved by any single formula. It was a complex and complicated problem involving different aspects of social and economic life. The cultivator had to contend against an environment uncongenial to better production. The tenure and tenancy laws sometimes discourage his whole-hearted efforts at proper cultivation. The inheritance laws helped fragmentation and sub-division of his small holdings into uneconomic units. Added to this he was forced to part with his produce during the harvest glut to meet the demands of the tax and rent collectors. The price of some of his produce is determined by a whirlpool of international forces over which he had no control. The various social and economic forces that tend to effect agricultural development had to be surveyed and eliminated. The farmer's problems are really the nation's problems. The state has therefore to step in and create an atmosphere for stimulating the maximum of economic production from each and every acre of cultivated land.

But agricultural production, unlike industrial production was not an exercise in simple arithmetic as tacitly assumed in some of our Five-year plans of food production. Uncertain elements affect agriculture, Varying variables play this part like soil-fertility, quality of seed, manuring, crop rotation, water supply, climate, rainfall, temperature, humidity, wind velocity, rain, sunlight, weed growth, pests and diseases and numerous other environmental factors. And each of these might be as important as any of the others in its effect on production depending on the quantity, time and duration of its incidence in the different stages of plant growth. Some of these could not be altered in the present state of knowledge but others could be changed for the better.

The Committee left aside all problems relating to social and economic spheres. It also left out of consideration incidental problems like industrialisation of the country, development of irrigation projects and various other long-term measures though it felt that there could be no hard and fast line of division between the short-term and long-term measures. Any measures could at once be a long-term and a short-term measure ; for instance, digging of wells to help agriculture was a short-term measure but if we are able to dig a number of wells in a tract where underground water was not available in plenty we have to take up the question of hydrographical survey and that was a long-term measure. If we wish to improve production by using improved seeds, it was a short-term measure but the development of improved seeds and the evolution of pest and disease resistant strains was a long-term measure. The Committee therefore felt that it should consider such of the factors affecting cultivation which could be changed for the better, within as short a time as possible.

Broadly speaking, there were two ways of improving production. One was by bringing more land under cultivation and the other by the intensive cultivation of the land already under cultivation. The Committee therefore took up the past recommendations of the Board on all these matters and suggested certain practical measures which could and should be tackled at once.

The first question related to land utilisation or development of waste land. In 1945 there was recommendation that provincial and regional boards of land utilisation should be set up without further delay and though three years have gone by no progress has been made. The committee therefore reiterated the same and suggested that there should be a survey of waste lands and sub-marginal lands with a view to put them to better use. The committee was of the opinion that the provincial land Utilisation Board should be given executive powers to carry out its plans. The Committee felt that the present efforts at reclamation of waste lands had not produced any tangible results and was therefore of the opinion that private enterprise should be encouraged by the grant of long-term leases and by subsidising the purchase of

necessary machinery and equipment required for reclamation and provision of irrigation. In Tinnevelly district, for instance, a private joint stock company had been formed for reclaiming waste lands and in six months they have reclaimed more than 1,000 acres, a feat which had not been achieved through any governmental organisation in Madras. The Committee also suggested that lands which were left hallow for a period of three years should be taken over by the Government and re-assigned to parties who were willing to cultivate them.

The next question considered was about the improvement of water supply by irrigation and other means. The Committee suggested that the Board might reiterate its previous recommendations, *viz.*, the continuance of the emergency measures now in force, conservation of rainfall, contour bunding, execution of irrigation projects, training of qualified personnel, adoption of measures to ensure better distribution of the existing supplies of canal water, the grant of loans on a more liberal scale etc.

The committee felt that these measures alone would not be sufficient and that the Government should provide for every district wherever necessary units of mechinacal excavators, power drills, air compressors etc. such as were used by the Military during the last war. The Government should make arrangements for the supply of small pumping sets to cultivators. The other day most of the members went to see the Poondi project and on the way they would have seen large areas cultivated by means of such pumping sets. If more of these sets could be had the ryot could certainly produce more food by bringing larger areas under wet cultivation. By the side of most river courses, water could be pumped up if the cultivators were supplied with pumping sets. If we want to produce more food, more pumping sets should be made in the country or imported from outside and made available to the ryots.

It must, however, be emphasized that digging of wells cannot be of lasting benefit unless steps are simultaneously taken to augument the supply of underground water. Hydro-graphical survey is immediately necessary and various measures that are adopted in other countries like construction of subsurface drams, recharge wells in the beds of reservoirs, afforestation of slopping terrain etc., should also be adopted here to increase the percolation of rain water as a safeguard against gradual desciccation of wells.

The next resolution considered was that the Government should provide better facilities and grant high priorities for the supply of coal, cement, brick etc., required for the construction of wells. Bund farmers should be made available in larger numbers for mechanically bunding up dry fields as a help to conserve rain water.

The construction of wells should be particularly encouraged in the delta areas in order to ensure the early sowing of paddy nurseries and early transplantation. Shallow wells should be sunk in the paddy

fields, to enable the raising of nurseries without waiting for the supplies of water in the Irrigation channels. Experiments in Madras have shown that early transplantation increased the yield of paddy. In the Godavari and Tanjore districts there are over 2 million acres of paddy fields where cultivation starts after the water is let into the irrigation channels, but if wells are sunk and cultivation is started early it is possible to increase the yield of paddy by 10 per cent. from this measure alone.

Subsidies should also be given for the excavation of small ponds not exceeding 10 per cent. in extent in paddy lands with a view to rear fish and raise nurseries. The earth removed from such ponds could be used to raise the level of the surrounding area to help production of fodder and vegetables. A pond 15 feet deep will contain enough water even in summer in some of the deltas in Madras.

The next aspect of the problem was the production of manures and manufacture of fertilisers. The committee reiterated what the Board had already recommended *viz.*, that assistance should be given by the Government of India to encourage the greater utilisation of composts made from town refuses. The committee felt that a certain amount of compulsion was necessary and required the Municipalities to take to the composting of municipal refuse.

The committee recommended that adequate provision should be made for the supply of ammonium sulphate and phosphatic fertilisers. There was a huge deposit of rock phosphates in Trichinopoly district, which is estimated to be 8 million tons. In the past we have tried unsuccessfully to make super-phosphate out of this and this year steps have been taken by the Madras Government to permit the erection of a 10,000 ton factory for the manufacture of fused phosphate from rock phosphates.

The manufacture of fertilisers has not received the attention it deserves. Our vision is so limited that we look upon the Sindhri factory with its estimated production of 3½ lakhs of tons as a tremendous achievement but it should be remembered that Madras alone can absorb three times the estimated production of the Sindhri factory. No doubt there is a limit to the production of Ammonium Sulphate as Ammonia is not a bye-product in the manufacture of coke as in other countries and the supply of coke, coal or charcoal is limited in our country. Our future development of agriculture depends on the manufacture of a nitrogenous fertiliser which can be made from the resources easily available in the country. The Nitrate of lime offers distinct possibilities of development as Nitric acid can be synthesised from the air with the help of electricity and Calcium is available in plenty. Norway has made rapid advances in the development of Calcium Nitrate as a fertiliser and if we can overcome the drawbacks of calcium nitrate, its deliquence and the difficulty in handling we should enter upon an era of revolutionary progress in Indian Agriculture.

The next resolution dealt with more intensive use of organic manures such as Farm Yard Manure, composts, oil cakes, green leaves and all waste products of agriculture. In this connection the possibilities of raising quick growing shrubs like Glyricidia maculata and of plants that were not browsed by goats like Galatropis, Adhatoda Vasica, wild indigo etc., on all waste lands, canal and tank bunds, sides of road and railway tracks and all places which were not put to more profitable use should be brought home to every cultivator. The tropical land lacks humus. We have to raise trees, plants and shrubs to get the organic matter necessary to add humus to the soil and the only way of doing it is to start growing more plants everywhere. A paddy grower might grow green manure in his field but this is not always possible, but there was one way in which this problem could be universally tackled and that was by growing suitable plants on the bunds of paddy fields. Experiments in Madras have showed that the paddy fields yielded about 20 per cent. more if 4,000 to 6,000 lbs. of green leaves were applied. A Glicricidia plant grown on a paddy field bund would produce every year 300 lbs. of leaves from the third year and in a paddy field there were over 400 yards of bund per acre. There was therefore no dearth of space for growing Glyricidia without deteriment to the yield of the paddy. Colotropis can also be successfully raised on the field bunds in sufficient quantity to supply the needs of the paddy crop.

The next resolution was about the conservation of farm yard manures and propaganda to stop the use of cattle dung as fuel. The ryot knows the value of the dung both as fuel and as manure, but if he can get other fuel he rarely uses the dung. Fuel can be readily supplied only by growing trees. The State must see that in every possible place rapid growing trees and shrubs are raised by the cultivator without detriment to cultivation.

The next resolution which looked rather novel was that there should be a prohibition against the indiscriminate rearing of goats by persons who had no facilities for the purpose and that licences should be issued for the rearing of goats. This measure is necessary to ensure that young plants and trees required for use as manure and fuel are not destroyed by these animals. The goats are the most destructive of all animals and the earlier we take steps to minimise the raveges of goats the sooner we will reach a better level of production. As the Vice-chairman said the other day, in New Zealand the shooting of goats was encouraged by giving money rewards. Similar measures are necessary in the interests of our forests and cultivated lands.

The next resolution related to the distribution of improved seeds. One practical difficulty we have experienced was in maintaining the purity of the seeds developed at great expense and labour in the research stations. The Agricultural Research Stations send out every year a small supply of nucleus seeds hardly sufficient for a few acres and we are supposed to spread these to all cultivated lands. A practical step

in achieving this would be to see that the seeds sent out from the Research Stations are developed in District Nucleus farms under the supervision of an expert. At present ill-paid demonstration maistries who do not know the importance of proper roguing are in charge of seed development in most provinces, but we must stop this penny-wise and pound-foolish policy which results in indiscriminate mixture of impure seeds. If there is a Crop Assistant to attend to the proper multiplication of improved seeds on 50 acres in every district it should be possible to cover all the paddy areas in Madras with pure seeds in the course of three years.

The seeds developed in the nucleus seed farms will be supplied to registered seed growers and it will be the responsibility of the Crop Assistant to test the seeds raised by the registered seed growers.

I must here invite special attention to an observation of the Committee which is of fundamental importance. The Five Year plan in Madras and possibly in other provinces contemplates spreading of improved seeds to millions of acres but no special provision has been made for manuring these lands. If we use the improved seeds and take away more of the nutrients from the soil we may reach a stage when the yield would go down unless we take simultaneous measures to manure the lands. A ryot cannot produce ammonium sulphate but he can plant shrubs and develop his supply of organic manures.

The committee has reiterated some of the previous suggestions regarding vegetable and fruit production and suggested that quick growing fruits like papayas, bannanas and pine-apples should be raised. Papayas should be raised for demonstration purposes in school gardens. In the South there was a good lot of prejudice against the papayas and if we raise the papayas inschool gardens and the school children get used to them it should be easy to overcome such prejudice. The Committee endorsed the recommendation of the Bengal Famine Commission that more root crops which would give more tonnage per acre should be raised.

As regards the manufacture of improved implements and farm equipment at a cost within the reach of the average cultivator the committee felt that the Government of India should call for a conference of agricultural engineers of all provinces and States. We do propaganda for the use of implements brought from other countries and developed to suit the soil conditions of foreign tracts : It was time we developed implements suited to our soils. The Indian ryot has been accused of using old-world implements like the country plough. But it should not be forgotten that the country plough was a cheap multi-purpose implement which could be used for ploughing, harrowing, drilling and other purposes. If we want to improve upon the indigenous implements we must develop implements which would have a multi-purpose object in view.

The Committee emphasized the importance of plant protection. If we neglected to protect the crops we cannot produce enough food. There should be closer integration of plant protection programmes of the different provinces as there was no point in tackling the pests in one area and allowing the infection to spread from another. Concerted measures are necesary for dealing with plant pests and diseases and legislation should be resorted to.

As regards publicity and propaganda the Committee desired that fuller co-operation of cultivators should be enlisted through organized bodies like co-operative societies, agricultural associations etc. Another important recommendation was that we should publish in popular language the results obtained in the experimental stations as at present very few outside the Agricultural Department were aware of these results. We should also make the fullest use of mobile cinemas in rural publicity.

There was also need to create an agricultural bias in the minds of young people and for this purpose the committee thought that the general principles of agriculture should be introduced in secondary and training school syllabuses and if possible in the elementary schools also.

The next resolution related to the Five-Year plan which envisaged the sale of seeds, manures and implements. At present agricultural graduates who have undergone training for three years in scientific agriculture are expected to sell groundnut cake, Ammonium Sulphate and seeds ! It is high time we entrust this work to non-technical men so that the agricultural officers might attend to their legitimate technical work.

The Committee was of the view that there should be at least one model agriculture village in each sub-division in places where fairs, festivals and weekly markets are usually held. In such places the advantages of adopting the recommendations of the Agricultural Department should be demonstrated in compact areas with view to convince the ryot about the advantages of the improved methods. Annual prizes might be awarded in each village to cultivators who produced the best results.

The committee was required to fix production targets for each unit of administration. To do this we must know the dietary habits of the people and the present level of production in the different states and provinces but the information on these points was not available. The committee has therefore suggested that the necessary data should be got from the provinces and States so that the matter could be pursued further.

I have briefly surveyed the various suggestions and recommendations of the Committee. This subject of food production has been dealt with on former occasions by this Board and there can be therefore no novel or startling suggestions. The only way in which more food can be

grown is by a rigorous application of known principles of scientific agriculture to the land. We have suggested many resolutions. If only we can make the State and the ryot resolve to adopt the resolutions and carry them out expeditiously we would have made a real contribution to the solution of this complex problem.

The Chairman said that the subjects dealt with by the committee were vitally important. It appeared that the committee had worked very hard and had achieved a great deal. He had no doubt that some of the recommendations made would be of great advantage to the ryots if they adopted them in practice. He noticed, however, that most of the points examined by the committee had been dealt with in the Memorandum of the Indian Council of Agricultural Research prepared by Sir Pheroze Kharegat, as its Vice-Chairman. It might have been much better and easier for the committee if those suggestions which were made in the Memorandum had been kept in view in examining the proposals. Had it been possible for the committee to find out to what extent the recommendations in the I.C.A.R. Memorandum had been implemented and what was still left over to be done, that would have been better still. The committee would then have been in a position to suggest something concrete. Judging from the importance of the matters it might have been necessary for the committee to discuss them more fully if they wished to consider them in the light of the previous recommendations. As such a detailed consideration was not now possible he thought that it would not be right for the Board to accept the recommendations in toto as some of the members might have some modifications or criticisms to suggest *Prima facie* most of the suggestions were very good indeed but he invited the opinion of the House if the Board should forward these recommendations to the provincial and State Governments asking them for their views. The I.C.A.R. might also be asked to state what action had been taken on the suggestions which had been forwarded to them before.

Sardar Harchand Singh, Patiala, said that it would be better to send these proposals to the provinces and States and to get their opinion.

Dr. H. S. Pruthi, Plant Protection Adviser to the Government of India, said that he was not in favour of the proposal and he felt that if they sent these recommendations to the provinces and States, they would certainly like to know what was the view of the Board. He did not think there would be much difference of opinion and he suggested that the members might be asked to offer suggestions for modifications, if any.

Mr. MacLean was in agreement with Dr. Pruthi and said that as far as he could see there was nothing novel in these recommendations. Most of them had been considered before and had already been put into operation. There was nothing contentious in the conclusions. With one recommendation, however, relating to the "poor men's cow" he was strucked by the courage of the committee in daring to recommend that the goat be destroyed or licensed. Apart from that, he did not think there was any contentious recommendatin and they might adopt them.

Rai Bahadur R. L. Sethi said that this question had been discussed many a time and it was for the Government of India to implement these suggestions. He would like to point out, however, that Mr. Sivaraman,

while rightly laying stress on the food crop, did not take into account the question of weed control. Some methods should be evolved for this purpose. If something could be done to control weeds, it would go a long way in increasing the food production. In America a good deal of money had been and is being spent on this aspect and they had evolved some sort of a machinery by which they claimed that one farmer in America could get as much as one thousand farmers in Japan. The I.C.A.R. had not sanctioned any scheme on the removal of weeds and if it took up this work or invited the various provincial or State Governments to submit schemes in this connection that would certainly be helpful. Mr. MacLead had said that Japan had been able to raise much higher yield per acre than India and suggested that a deputation should be sent to that country to find out what particular methods were adopted there. In spite of all they were doing, the yields were going down and down. This was a very serious matter and if a man was deputed to write a small note or a small booklet in six months it would be very helpful to the country and the I.C.A.R. could publish it for information.

The third suggestion in this connection was made by Dr. Desai on the production of gas from cow dung. This should be considered by the Board. In this connection there had been a suggestion to study the experiments that were being carried on in China in making compost from waste products. The committee felt that no progress had been made in India in the matter of production of composts from waste products of urban areas and recommended that the making of composts should be made obligatory in cities and municipalities and wherever organised panchayats existed.

There are the three items on which some action might be possible to take, otherwise the note of the committee might be recorded and the work appreciated. Dr. J. N. Mukherjee said that the committee had taken great pains in practically laying down categorically the various ideas and items of work which had a bearing on the improvement in agriculture. Their thanks were due to the committee for bringing within a short compass a few important points which had been dealt with in many publications. He had, however, one difficulty and that was that so far as he could read from the terms of reference of the committee it was perhaps expected that the recommendations would deal specifically with measures to be taken from the short range and long range point of view to maximise the production of food. particularly in India consequent on the division of the country. That seemed to be the most important part of the terms of reference. Now what was the result of the division of the country? The general problems were there before the division of the country into Pakistan and India and still they were there. But after the division of the country three important commodities, *viz.*, cereals, jute and cotton, had become insufficient from the production point of view in the Indian Dominion. The question now was how to increase the yields of these commodities? It would have been much better if the committee had made some suggestions about this.

Secondly because of the absence of relevant information and data it was not possible for the committee to suggest something concrete for crop planning. So far as the report was concerned it was not possible for the committee, for the reasons explained, to make specific recommendations as was expected. Therefore in view of these facts he was inclined to think

that the latter of the two alternatives suggested by the Chairman would be better, namely that the Board might say that the general aspects of agriculture, improvement and production in India had been dealt with by the Kharegat Memorandum and the committee had examined the subject in detail and had collected the essential points. The attention of the provincial and State Governments might then be drawn to the suggestion and they might be asked to say how far the recommendations in the Kharegat Memorandum had been implemented and what they thought about the various suggestions made by the present committee. The question of cereals, cotton and jute might be referred to specifically. On receipt of replies it might be considered as to what steps could be taken. Coming to the actual recommendations, while he agreed fully with most of them, there was certain difference in the sphere of feasibility. When they made a recommendation they had to see that the recommendations were feasible. On the points of desirability there was no difference of opinion but only on the question of feasibility. Taking the question of pumps, if they were of deep boring types and engines were to be used then they would require to be driven by petrol. Already there was a shortage of petrol and the Government of India were thinking of getting petrol from coal. It was not difficult to fit in a thousand pumps or even tens of thousands and hundreds of thousands, for they were sending 80 crores of rupees to other countries for the purchase of food stuffs. He thought he would not be misunderstood if he pointed out the practical difficulty. There was no means for running this scheme. There might be a possibility that they might not have any petrol in reserve as it might be required for Defence purposes. The next question was of phosphate. It might not react under all conditions of soil and there should not be a general resolution.

Mr. C. A. MacLean supported Dr. Mukherjee's views.

Mr. Chavan, Bombay, said that under protection, they stressed only protection against insect pests. He thought the major trouble was the animal pests. They found that bats and particularly monkeys had been doing ravages with the crop and there were still sentiments against such animals. While they were shooting human beings why animal pests which were responsible for great damage to this crop should not be destroyed? The departments had been recommending that licences for fire arms should be issued. In Bombay, even if licences were issued to the people they were not able to get guns as they were not manufactured in India and lot of difficulty was experienced in procuring them.

The second proposition was the protection of the farmer's land. Lot of areas were going waste and had gone waste on account of the ravages of the wild animals particularly in the forest regions. There was large areas in Bombay which could be developed. Then there were weeds. They had been trying to do away with weeds but with little success. There was a great scope for this type of work by which land areas could be increased.

Dr. Bal supported fully what Dr. Mukherjee had said but in view of the difficulty in the collection of the data he suggested that it would be desirable to impress upon the Government of India to take the census at an early date and collect the data crop-wise.

Mr. P. Chatterji referred to resolution No. 3 in connection with manures and fertilizers where it was stated that a continued assistance from Central Government was necessary. While he agreed with the spirit of the resolution he invited attention to one very important aspect suggested in Dr. Keen's report on "The Agricultural Development of the Middle East", in regard to the ultimate fate of organic matter in the soil. Dr. Keen said that the way in which the changes occured in the soil had generally been studied more under temperate, than under tropical, climate and the inference drawn from results of temperate regions was not probably applicable to the other region. The decomposition of organic matter in the soil was essentially a process of oxidation and under the Middle East conditions the nitrogenous plant nutrients might be lost as gaseous products. The same applied under Indian condition. The result was that whatever organic matter, such as cattle dung, compost, etc., was applied it was oxidised within a short period leaving the mineral residue, as if the organic matter had been burnt and ash left. Dr. Keen had therefore pointed out that unless some system of husbandry could be devised in which the crop could utilize a good proportion of nitrogen, the advocacy of increased organic manuring as a means of increasing soil fertility was hardly justified. If a small proportion of its nitrogenous part was utilized by the plant, it offered a good case for the usual custom so generally condemned for using dung as fuel as this would leave the mineral nutrients as ash which could be returned to the soil and in which form it was more readily assimilable.

Mr. Chatterji then referred to the question of compost making and said that its preparation involved much cost and transport charges of such material from town refuse would also be appreciable. Its economics needed study. On the other hand green manuring did not offer any such difficulties. It provided plenty of organic matter and leguminous green crops enriched the soil through the fixation of atmospheric nitrogen. The cost too was much less.

The third point was in connection with the growing of trees for fuel in order that farm yard manure could be conserved. He found that the growing of trees was generally done in a haphazard manner and suggested that this should be done on a planned basis, so that cutting and felling might be regulated and selection and arrangement could be designed in a planned and artistic manner, yielding an economic return of fuel.

Mr. Laxaman Rao, Superintending Engineer, Mysore, said that under Recommendation No. 2, improvement of water supplies by irrigation and other means, an item for the construction of high reservoirs should be added, as water was an essential requirement for agriculture. In order to step up food production it was necessary to increase the water resources. For increasing large quantities of water, it would be advisable to construct large reservoirs to harness the river waters that went waste, and turn them to land for the service of agriculture.

The Chairman said that it had been proposed by Dr. Mukherjee and seconded by Mr. Maclean that they should send these recommendations to the provinces and States. Similar recommendations as had now been made had already been forwarded and the Board would very much like to know as to what had been done and what remained to be done. On receipt of all

the replies, this matter might be considered either at the I.C.A.R. meeting or by a special committee.

Dr. J. K. Basu inquired whether all the points raised by the various members would be incorporated in the circular.

The Chairman said that they had discussed the report generally but had not examined the recommendations point by point. The recommendations would be forwarded to the provinces, and States as suggested by him. It would not be right to communicate the various opinions expressed by members at this stage.

The Board agreed to the Chairman's suggestion.

SUBJECT No. VI.

To review the measures adopted to increase the fodder production by:—

(a) selection and propagation of perennial cultivated grass,

(b) improvement in rotational grazing,

(c) exploration of new fodder crops in addition to improving the existing ones.

(For report of the committee see Appendix VI).

Dr. Parija, the Chairman of the Committee, in introducing the subject, said that the committee hold a general discussion and came to the conclusion that no systematic studies of these grasses had been made although in some provinces and at the I.A.R.I. some work had been done but the work had not progressed far enough to lead to any definite conclusions. They also realised that in the provinces there was no special staff to study these problems and noted that the cultivator had not taken up the cultivation of fodder crop because he did not appreciate the indirect benefits which might be received by growing these crops. So, the resolutions that were formulated were based on these considerations. The first resolution dealt with the suggestion that the provinces and the States should establish their Agrostological sections to study the problems from all aspects regarding fodder cultivation and increase of its cultivation. The second resolution was that the cultivators should get suitable grasses and legumes recommended to them by the departments of agriculture and/or animal husbandry and that they should be encouraged to grow fodder by giving them certain concessions. These concessions should be subsidised by sale of seed, bounties and cash concessions in water rates and in certain areas where assessment was made for tax fodder cultivation should be exempted or abatement of tax should be allowed. The committee also suggested that the department to be created for agrostology should study the comparative merits of various grasses and their nutritive values and suggest most suitable grasses to the cultivators.

The next question was the possibility of utilising waste lands in the villages. The suggestion was that field bunds and tank banks should be explored. In this connection the committee recalled the resolution that had been passed at the sixth meeting. This resolution suggested the creation of land utilisation boards in the various provinces. While discussing the utilisation of waste lands the forest officers present at the committee stated that they were dealing with forest lands. There should be some authority to deal with the waste lands in other areas but there was no such authority at present. The Revenue Department was not likely to undertake this. Therefore the committee recommended that Land Utilization Boards should be created forthwith in the provinces and their members should be entrusted with the management and planning of fodder cultivation in waste land in their jurisdictions.

The next point related to rotational grazing. The information available to the committee showed that in some provinces rotational grazing had been tried with success. But there were certain difficulties that came to the notice of the committee. The first one was that there was not sufficient water supply for the cattle in the area let off for grazing and it was necessary that with improved rotational grazing steps should be taken to supply adequate water to the animals. The second difficulty was that reserved areas even in the forest were covered by useless shrubs hampering management. It was therefore suggested that these shrubs should be removed in order to make the land fit for grazing and the growth of grasses. Here also the Land Utilization Boards came in because they should make plans for rotational grazing even in waste lands outside the forest area. Regarding exploration of new fodder crops in addition to improving the existing ones, the Committee came to the conclusion that the proposed agrostological section should be entrusted with this work. It should undertake the collection of various types of grasses and other fodder crops and if necessary the centre should collect these plants where the provinces were not able to collect and supply them to the provinces for trial. Then they also suggested certain crops whose seed was pure and those working on fodder crops said that Berseem was a crop which did not easily set seed. The Committee was of opinion that steps should be taken to improve the setting of seed. They also suggested that the farmers might be encouraged to keep bee-hives because bees helped in the setting of seed. Last of all it was felt that there was no complete illustrated hand-book in India on fodder and grasses and other forage plants like legume and the recommendation was the I.C.A.R. might undertake the compilation of such a book which would be of use to those who were concerned in pasture management and fodder cultivation.

Rai Bahadur R. L. Sethi said that in regard to the production of grass seeds in the waste lands, a suggestion had been made by Mr. Banerjee in one of his notes on "Grazing problems in the sub-marginal lands" that lands outside the forest areas with a certain slope when covered up with grasses and fodders, would not only be helpful in increasing the fodder supply but would also be very helpful in checking erosion. The committee probably had not taken that into consideration but this was very important. Action should be taken to conduct a survey of grasses in those areas, if not already done. I.C.A.R. might invite schemes about this.

The other thing was that a lot of grases was available in the reserved areas but little outside the forest. It was suggested that transport facilities should be provided by the Government. The committee had not made any recommendation in this respect. In connection with the arrangement for the supply of seeds to the cultivator stress had been laid on the supply of berseem. It was not only the supply but the production that presented difficulty. This was due to the fact that good seed could not be produced. Formerly good seeds were obtained from places outside India and the difficulty had now arisen due to changed circumstances. Definite action was necessary to ensure the production of berseem and other fodder crops. The I.C.A.R. had already made a request to the Australian Government, who were sending an expedition to South America for collection of grasses and fodder crops to collect some on India's behalf. The material, if received, would be of great benefit. He was not, however, in favour of subsidies to growers because experience had shown that once the seed could be produced, the cultivator took to the cultivation of seeds on their own. He thought that neither propaganda nor subsidy was called for.

Dr. Mukherjee said that he welcomed the recommendations of the committee which did great service by drawing attention to certain aspects on which action could be taken immediately. Regarding forest grazing land he was not aware if any systematic attempt had been made to improve the grazing areas by deliberately introducing legumes which would improve the nutritive quality or the yields. There was a great field for work on this. Secondly, they had to take into account that many of these forests were inaccessible and distributed in pockets in the country. People had to depend on what they could get as waste product of agriculture such as straw, very poor quality of grass, etc., and that too not in sufficient quantity. Therefore they should think out what could be done. The most important thing was to consider the possibility of introducing legumes in crop rotation. It was a question of selecting them properly and fitting them to particular regions as also in the crop system. The idea of starting agrostological sections was very welcome. Simultaneously with the botanical aspect, they had to consider also aspects like manuring. Proper manuring of legume was also very much necessary. There was, an obvious omission of this. The members of this committee must have got this in view but some specific mention must be made of the aspect. They must also search for suitable types of grasses. Australian experience had shown that often certain types of grass failed when an attempt was made to introduce them in another country.

Regarding the question of encouraging the peasants, he was afraid, he differed a little from Rai Bahadur Sethi. He did not see why people should fight shy of making contributions and subsidising the poor tillers of the soil. Regarding the possibility of utilizing waste lands the main thing was to arrive at some sort of land classification. They should not proceed blindly, but should first find out the methods definitely, how to do it and what were the best uses to which a land could be put to. Having arrived at a broad conclusion, they could plan out.

Rai Bahadur Kalidas Sawhney said that a greater part of the country received rain during limited intervals and it was necessary that they should recommend some measures for conserving what they produced during the rainy season. He suggested therefore that the recommendations

should include (1) ensilage of forest grasses and (2) preparation of hay and pressing it into bales. During the war, large quantities of hay were preserved in different parts of the country. Hay bales could be preserved during the season when fresh grass was available. He stressed that something of that type should be attempted as a regular means of conserving fodder supplies and a definite recommendation should be made on the subject.

Mr. Cherian Jacob, Coimbatore, said that in Madras Province they introduced rotational grazing in 9 large forest areas and in all of them except probably one it was a grand success, they could even put double the number of cattle in the same area.

Dr. Mukherjee asked whether any legumes were specifically introduced in the forest areas to improve the quality.

Mr. Cherian Jacob said that Madras was mostly a dry area and therefore there was no perennial Legume to be grown all the year round. They grew in the Northern districts of the Madras Province Sunhemp and Phaseolus trilobus in rotation with paddy in about half-a-million acres. About a week before the harvest of paddy Sunhemp seeds were sown in the standing paddy crop and in about 70 days time it came to flower and at that time it would be about 2½ feet in height and at that stage, the top half of it was cut and left in the filed to dry and when dry, it was stacked in laternate layers with paddy straw, thereby the nutritive ratio of the paddy roughage was very much increased. The bottom half was ploughed into the soil as green manure. That practice being beneficial both to cattle and paddy crop, he recommended it to be grown in all paddy growing areas throughout India. Those duel purpose Legumes benefited both cattle and paddy crop. Without the efforts of the Agricultural Department the ryots of those districts were growing those fodder-cum-green manure plants for a good many years then.

He was growing a dozen important perennial fodder grasses collected from the forests and waste lands at the Central Farm, Coimbatore for the last one-a-half decades. He was able to get three harvests of fodder beginning from the end of October even though the average rainfall at Coimbatore was only 20 in. per annum. He pointed out at one of the meetings of the Provincial Fodder and Grazing Committe that if an harvest of fodder was taken in October-November another harvest could be taken in December-January thereby cent. percent. increase in the output of fodder could be affected. One important point to be observed in that connection was to conserve every drop of rain water received by bunding or trenching along the countours.

As regards an Agrostologist, as far back as 1919, Madras had sanctioned a post but that post was not filled up. He was glad that the committee had definitely recommended the appointment of an Agrostologist and the creation of a section.

Mr. Jacob said that there were lakhs of acres lying waste or covered with shrubs which were of no use to any one. Grasses required least depth of soil. If one wanted to cover the earth or any portion of earth without much attention for the needs of men grass was the easiest and quickest for such purpose. All waste land should be used not only for covering with

grass but should be broken up and sown with suitable indigenous grasses so that they could find out definitely under cultivated conditions whether they could increase the yield. In the efforts to grow food crops for men people generally were unwilling to try anything else. It was a very sorry state of affairs. He requested that this Conference should recommend to the Governments concerned that every effort should be made to see that green fodders were cultivated with all the help that the State could extend. He found that in Coimbatore people took some interest in the Kangayam tract where the Kangayam breeds of cattle were bred. These areas were ploughed once a year and there were babul trees. The grass grew well. These areas were also ploughed once in five years and sown with a mixture of Serghum. When the crop was removed, the grass was allowed to grow.

Mr. Sivaraman said that he fully endorsed the recommendations of this committee and also the suggestions of Rai Bahadur Sawhney about silage. The possibility of utilising the sewage water of the municipalities might also be explored. In Madura they had a Sewage Farm running for about 25 years and they were growing many grasses. The production of grass there was phenomenal, about 100 tons per acre. The Hon'ble Premier in his speech pointed out that in Madras city they were wasting the sewage water into the sea. In going into the question of profitable utilization of this water they were faced with certain difficulties. The land where it could be easily taken to had to be studied. Experience in Madura and Bangalore showed that if such soils were grown with grass and irrigated with sewage water, they would show a great improvement. The problem of sewage sickness also had to be investigated. In respect of other recommendations, in so far as Madras was concerned, they already put up a scheme for opening an Agrostological Section and they were going to carry out research in grass and fodder grasses and the scheme would be sent to the I.C.A.R. in due course. They were also conducting experiments on some of the exotic grasses and found that one type of Australian grass was highly drought resistant. He suggested that the trials of this grass be taken up in other parts of the country also.

Mr. J. Ali said that in Bombay also there was a great scope with a large number of areas which could be multiplied and probably legumes and grasses could be grown. Not only could it improve the value of the pasture areas but it would also be useful for preventing erosion on slopes and pasture lands. The committee had made very important recommendations. As a lot of grass area lay in the forest, it was necessary to get the full co-operation of the Forest Department in regard to the improvement of the pasture areas there. Dr. Mukherjee had raised the question of introducing legumes in the grass land. This was connected with the question of re-seeding the legumes grass mixture consisting of four or five varieties. Some work in the provinces had shown that when the area was re-seeded, one or two varieties were found to be suitable and they were able to eliminate the undesirable varieties. Another point was that in the forest areas sometimes there were grasses which were not of much nutritional value. Such poor grass had been wiped out by the introduction of a grass mixture consisting of certain legumes. In this case also the work done there had shown that if these grasses were cut or ensilaged before they came into flower, they could be made use of, otherwise they

would be absolutely lost. In addition to that, there was the question of the prevention of soil erosion. Suitable grass mixtures had to be selected which may be of high nutritive value which may be efficient also from the point of soil saving. He therefore suggested for the consideration of the House that some suitable recommendations might be made seeking the co-operation of the Forest Department as the grasses were mostly found in the forests. The cultivators had little areas in which to grow grass. In regard to the fodder grass the Agricultural Departments should shoulder the work, but Forest Department's co-operation must be sought in regard to others.

Mr. Jabar Ali said that an experiment was going on at Kandiville where grasses were grown on the side of the roads along with some leguminous trees for shade. Whenever they made up a collection of grasses they also collected a certain amount of leguminous growth and the two together made excellent fodder. From the last two years working they were able to collect 250,000 lbs. of fodder during the year. This would be helpful in solving this problem of fodder and he would like to bring this to the notice of the Board.

Rai Bahadur Sethi said that besides leguminous grass attention should also be paid to the breeding of root fodder like mangolds and other crops. A recommendation to that effect had been made by Dr. Pal in his paper and a recommendation of that nature had been made in the resolution.

Dr. Parija referred to the remarks of Mr. Sethi and said that the committee had read all the papers given to them and they thought that the suggestion in question had already been included in the resolutions. It was suggested that the Land Utilisation Board should be entrusted with the planning of fodder production in waste lands and those lands which were sub-marginal and waste. The second thing was that transport facility should be provided. The Committee considered this and the Forest Officers present there said that this was impracticable. As to seed production he said that seed production also must be assigned proper importance.

The committee recommended that arrangements should be made for supplying to the cultivators seeds of recommended fodder crops particularly Berseem, but as the seeds of these were not easily available, either they should be purchased from abroad or produced in the country. That was why no separate recommendation had been made about seed production. Regarding subsidy, their experience in other provinces was that cultivators were not taking to growing fodder grasses. It was a matter of national importance to produce more milk which was protective food and the members of the committee were unanimous that some concession should be given to the cultivator so that he might be encouraged to put some land under fodder crop. Once he realised the benefit he would take to it most willingly without any further subsidy or encouragement. This was the principle underlying the Grow-More-Food Compaign. They were following that. Hence the committee unanimously recommended that some concession should be given for the collection of new fodder plants. They were glad that the I.C A.R. had already taken some action. Regarding Dr. Mukherjee's point about manuring of legumes, this was also

covered by the Resolutions. It had been suggested that the Agrostological Section should be entrusted with the collection of grasses.

Regarding Mr. Cherian Jacob's suggestion about conservation of moisture, it had been included in a resolution where it was said that moisture should be conserved in those areas where the land was sloping and the *rain water ran off; whether in the hills, sub-marginal forest lands or plains.* He supposed that Mr. Jacob wanted inclusion of moisture conservation in plains also *if the land was slopy and the rain water ran off.* The committee thought that the moisture *conservation* required was for sloping areas and not for plains *if the rain water did not run off.*

The Chairman said that from the discussion, it appeared that it would be necessary to add one Resolution to those recommended by the Committee. That was about seeking the cooperation of Forest Departments for purposes of making hay and ensilaging it.

The Board agreed with the Chairman and adopted the following resolution:—

"That in order to conserve fodder resources during the rainy season the Forest Departments might be requested to cooperate in making hay and silage apart from rotational grazing".

The following Resolutions were then adopted:—

A. (1) That in each Province and State, there should be an Agrostological Section to study the problem in all its aspects which will include (a) collection of grasses (both indigenous and exotic) (b) their trial under local conditions, and (c) their cultural, manurial and hygienic requirements. The Central Government should help the Provinces and States by collecting suitable and forage plants and supplying them for trial.

(2) That the Departments of Agriculture and|or Animal Husbandry should undertake immediate experiments under comparable conditions to work out comparative data regarding economic and nutritive returns from the perennial grasses at present known and the alternative cultivated fodder.

(3) The Departments of Agriculture, and|or Animal Husbandry in the Provinces and States should recommend to the cultivators suitable grasses and legumes for growing as fodder encourage them by means of concessions in the form of subsidised sales of seeds, bounties in cash, concession in water-rates and|or abatement of assessment for fodder cultivation.

(4) That the possibility of utilising waste lands in the villages field bunds and tank banks should be explored for growing suitable perennial and other fodder and forage plants. The attention of Irrigation Departments should be invited to the possibility of growing perennial grasses along irrigation channels.

B. (1) Rotational grazing has recently been tried with success in some parts of India. The Committee strongly recommends that this system should be extended to suitable forest and waste lands in the Provinces and States, and that the carrying capacity of such lands should be studied

simultaneously. In this connection, the Committee is of opinion that the Land Utilisation Boards contemplated in Resolution No. 1 on Subject No. II of the 6th meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry should be entrusted with the planning of fodder production in waste lands.

(2) That in order to improve rotational grazing, (a) steps should be taken to provide watering facilities for cattle, (b) useless scrub jungles should be removed and (c) moisture should be conserved in those areas where the land is sloping.

(3) That in order to conserve fodder resources during the rainy season the Forest Department might be requested to cooperate in making hay and silage apart from rotational grazing.

C. (1) The Committee is aware that work is being done in the Provinces and States for the improvement of existing fodder crops; but there is much scope for more intensive work in this direction. The Committee recommends that the new Agrostological Sections suggested in Resolution A(1) be entrusted with this work.

(2) As there is great scope for exploration of new fodder crops, attempts should be made to utilise plants which have not so far been used as fodder crops and also new plants including perennial legumes (both indigenous and exotic) should be collected, to be tried as fodder. In judging the suitability of fodder crops, its nutritive value and its toxicity to animals should be investigated before it is recommended.

(3) Arrangements should be made for supplying to the cultivator seeds of recommended fodder crops, particularly Berseem, the seeds of which are not easily available. The possibility of utilising bees for securing better setting of seeds in crops like *Berseem* should be explored.

D. That the Committee feels the necessity for an illustrated hand-book on Indian Fodder and Forage Plants and suggests that the Indian Council of Agricultural Research may undertake its compilation.

SUBJECT No. 7.

The rotation of crops which will give the best results in an irrigation intensity of 35 to 70 *acres* in 100 *acres*.

(*For proceedings of the Sub Committee No. VII see Appendix VII*).

At the invitation of the Chairman of the Board Mr. Venkatachari the Chairman of the Committee, opened discussions by saying that the subject was one relating to rotation of crops which would give the best results in an irrigated intensity from 35 to 70 acres out of a block of 100 acres. This subject was discussed for a considerable time before the Central Board of Irrigation and the problem was one peculiar to Northern India particularly the provinces of Punjab and possibly U.P. and other districts round about these provinces. In the south they did not know of anything like that at all. The intensity there was 100 per cent. or even more. So, to begin with they had some difficulty in understanding what

exactly was the difficulty in Northern India. The representative from Bikaner and Dr. Raheja explained the system of irrigation obtaining in Northern India and the conditions under which it was necessary to have a low intensity on the irrigated areas. The main problem was the rise of water table and the poor quality of the soil. And again, while crops in Madras consisted mainly of rice, the crops in Northern were of the type of irrigated dry crops. In their new projects they were also initiating a system of irrigated dry crops as soon as the Tungabhadra project was executed in Madras, Lakkavali dam in Mysore and Lower Bhavani in Coimbatore. When these projects were completed, they would have large scale experiments conducted on irrigational dry crops. Even in those areas they had adopted an intensity of 100 per cent. The committee felt that it would be useful to suggest rotation on an all India basis and to enlarge the scope of the work so that instead of limiting the intensity to 70 or 30 to 70 per cent., it might cover the ranges of over 70 and possibly also over 100. It was considered desirable to define the term intensity so that people who were not acquainted with the system of cultivation might thoroughly understand the scope of the treatment. It was also felt that the papers were incomplete in some respects because it made no reference to the previous subjects which had been included under this very heading in last year's sub-committee. During the committee meeting, the Secretary of the Council was good enough to circulate a note which showed that not only other subjects were considered by the previous committee but also there was a record of the progress made. The main scope of the subject which was put before the committee having been enlarged to deal with all kinds of intensities, the subject as it emerged from the committee might be more or less described as a system of rotational crop for any given intensity suitable to the area.

An attempt had been made to define the term 'irrigation intensity' and the draft resolution on the subject was an attempt defining this in a manner which would help the committee and also the other members to follow what exactly they meant by this term. The next one was an attempt to enlarge the scope of the reference intensity as 70 per cent. and intensity lower than 35.

There were areas where the irrigation intensities were less than 35 per cent. They dealt with the factors affecting the determination of intensities. They made reference to the observations so far made and discussed the papers, the results as far as made available and the lines of future work.

Under (a) they had drawn up a resolution about the intensity of irrigation, under (b) and (c) they had no resolutions to propose, and under (d) they had proposed a series of resolutions mainly relating to the future work to be undertaken in this connection. The next part of it dealt with the results which suggested further lines of work. Under "*Organisation*" they said that the help of existing organisations was inadequate and that a great deal of expansion was necessary. It was suggested that where existing organizations were available they should be expanded and where new organizations were necessary they should be set up. In regard to the "Scheme of experiments" they tried to give an idea as to what they considered important in relation to the rotation of crop, some of which might be known to most of the workers in the field. But the committee

felt that it must put up in some definite lines so that especially in these days when the lines of work in different provinces differed and some of the juniors might not have mature advice, they would exactly know what the committee had in mind. Even at the risk of repetition they thought it better to mention all the things, which they thought might have a bearing on this point. They also drew attention to the work that had been done in certain typical farms in the Punjab, the U.P., Bihar, Bombay and also in Madras, just to save the time of workers. Lastly, they said that experiments conducted should be analysed and should take definite shape. Probably everyone of this would be necessary for record but it was far better to mention them so that people might know that some thing or other had not been ommitted.

Rai Bahadur Sethi wanted to know, as to what extent the work was in progress in this connection in different parts of India. It was not clear from the notes or other data as to what amount of work had been carried out in finding out a suitable rotation under different conditions in India and whether that work had been supervised by the Agriculture and Irrigation Department in India.

Dr. Mukherjee said that in determining the best system of rotation, they should know the water requirements of crops, and Rai Bahadur Sethi had enquired about what had been done in other places. But there was one factor to which attention had been given in some places, and that was the losses incurred as regards water. The figures obtained by the Poona Research Laboratory showed that the loss was of the order of 60 in. and in sugarcane he thought it was about 56 in. or 60 in., i.e., about an equal quantity, if not more, was lost. The judicious and controlled use of water was a matter of great importance. It was possible to save an appreciable percentage and if that was so, they could increase correspondingly the acreage, or choose a better system of crop rotation which would ensure the saving in water. Now the experiments in water requirements except some did not always work out a thorough balance sheet of the water used on the soil and that utilised by the plant. The depth of penetration of the water was an item of great importance and also the interval which should follow to do this it would be necessary to undertake a very expensive layout of the experiments as also to examine the distribution in different depths, and to study the physiological aspects of plants, moisture content, *etc.* The prevailing system in India was such that an Irrigation Engineer would say "Here is the water and I can give you this quantity in this way. Do what you can". But reorientation from the point of view of the plant physiologist and the soil scientist was necessary for the latter would say "this is what I require and at this time. You please arrange your irrigation so that I can arrange for the quantity at the time when the plant needs it".

Mr. Acharya said that with regard to the actual water-requirements, and the rotation of crops, no definite experiments had been actually carried out in regular plots where rotation had been practised. It was only in connection with crops like sugarcane or rice and wheat, that some water requirements trials had been carried out. Particularly in the case of rice only some experiments had been carried out in the Madras Presidency. Therefore sufficient data were not available and it was felt that in case they

wanted to get any results they must plan out experiments relating to the subject for consideration by the Board. Dr. Mukherjee had raised the question of percolation of water. This fact had been studied by the Irrigation Research Laboratory at Lahore in connection with the water logging problem in relation to irrigation and they had found that for different heights of water table different amount of water rose in the soil, for instance in the case of cotton they found that something like 9 in. to 12 in. of water would rise in the season and in the case of wheat 5 in. to 6 in. Like that they had worked out the percolation losses but there was no definite record in relation to rotation. In order that the data should be collected the committee recommended that "the rise and fall of water supplies and quality of ground water in relation to water" should be studied. As regards the balance-sheet and the data on water supply, the committee felt that no data were available and they recommended that "the conditions of water table and its relation to season and rainfall and irrigation resources should be studied". This recommendation was made because data were not available on the various problems.

Rai Bahadur Kalidas Sawhney said that as the Chairman of the committee had himself pointed out, this subject was very difficult. Personally he believed that the subject was of a very limited importance except in areas like the Punjab, Bikaner and some parts of the U.P. The notes that were submitted to the committee did not appear to give full details on the basis of which it should have been possible for the committee to make any definite recommendations. Therefore he suggested that the recommendation of this Board should be only this:—

> "That this Board recommends to the Agricultural Departments of the areas in which this subject is of some importance, that they should carry out systematised rotational experiments to find out which is the best solution under those particular conditions".

He said that, on the available data, it would not be in order for the Board to make any recommendation whatever.

Mr. Vijayaraghavan said that he had been asked by the Chief Engineer and his Director to speak of the results obtained at the Irrigation Research Station, Siruguppa, in the Bellary district. That station was established in Tungabhadra Project area where it was proposed to have irrigated dryland crops and not rice. The soil being of heavy clay over disintegrating rock of geness origin, some held the view that clayey soil there would be water-logging; in other words some apprehended a perched water table, if those soils were irrigated. The soil survey conducted in that region prior to the establishment of the station showed that the very slow permeability of the soil itself would be helping no percolation of water below for raising the water table of the tract. Later on when the station was established the results showed that there was no fear of perched water table. On the other hand there was evidence to show that irrigation water moved from the top downwards, even in the disintegrating subsoil region also. Therefore the preliminary apprehension that irrigation of those black soils would create water logging proved false.

Coming to the study of rotation of crops in the region, between Irrigation and Agricultural Departments, it was still not conclusive what

amount of water should be given in two blocks, one known as *mungari* or *kharif*, and the other *hingari* or *rabi*, or whether the *mungari* of one year should be rotated with the *rabi* of next year, etc. They were still experimenting and conclusions were yet to be obtained, but the broad indications were that in the kharif season, irrigated cereals had been quite a success, whereas in the rabi irrigated cotton gave good result. They had yet to find out a good variety of irrigated jowar to give a good yield. When one examined when the irrigated jowar was cultivated in the country it was found that it was cultivated in the summer months. Jowar did not require much water. Few grew jowar in the rabi season with irrigation because their rabi was not strictly rainless winter. If Jowar was grown when there was rain the soil being clayey, with very good moisture retentivity and if one the top of it, it was irrigated, the result was that the young jowar seedlings got attacked by what was known as the *jowar fly*. For the insects the conditions were very favourable. The incidence of the jowar fly had been the main cause for the failure of jowar in the rabi season and there had been attempts to breed a jowar that would withstand the insects. Therefore, broadly speaking, in the kharif season cereals like jowar, Italian millets, ragi, etc., were quite a success, and cotton had been very poor; while in the Rabi season cereals had been poor and cotton had been quite a success.

Dr. J. K. Basu, said that in the draft resolution on page 2 the sub-committee recommended that the subject included in the agenda might be enlarged in scope to indude irrigation intensities greater than 70 acres per 100 acres. It might therefore be worded as follows:—

"Item I (d). The rotation of crops which will give the best results in—

(i) irrigation intensity of 25 to 70 acres in 100 acres,

(ii) irrigation intensity greater than 70 acres in 100 acres."

He further said that the sub-Committee discussed the subject 7-1(d) under the following head:—

"(a) definition of intensity of irrigation,

(b) factors affecting determination of intensity of irrigation and rotation of crops in relation to

(i) soil conditions,

(ii) climatic conditions,

(iii) irrigation supplies available,

(iv) water table.

(c) observation so far made and summary of results,

(d) suggestion for future work,

(i) organisation,

(ii) scheme of experiments,

(iii) collection of data.

(e) any other subjects."

A draft resolution under (a) had been framed and put up before the board.

As regards (b) and (c) the notes were recorded and the sub-committee had no recommendations to make.

As regards (d) (i) the sub-committee proposed the following resolution for adoption:—

"d(i) *Organisation.*—The sub-committee recommends that the existing research organisations in the various provinces and states should be enlarged and expanded to the extent necessary and new organisations set up where none are available to study and carry out experiments on a co-ordinated basis on rotation of crops both on experimental stations and on cultivator's fields". In his opinion if the Board was to recommend any resolution it should include both, so that it would be applicable throughout India.

The next point was about the question of soil tracts. In working up the intensity of irrigation they must take into consideration the nature of the soil. In sugarcane substations with certain type of soil, it was possible to have one irrigated crop in one year, in shallow type soil, one irrigated crop in two years, in medium type of soil and they had one irrigated crop in three years in the deeper soil. Keeping these factors in view, they had summed up that in future experiments the work should be done on the lines so laid down in the proceedings of the sub-committee under Item 1(d) draft resolution under sub-head d(ii).

He then referred to No. (ix), *viz.*, "with a view to study long term effects of crops in soils, experiments should cover at least three rotational appearing in each year" and said that this was very important. Most of the experiments were usually carried for one cycle only and hence they did not take into consideration the effect of the rotation on the soil.

Regarding No. d(iii) he said that data should be collected on the basis of the recommendations throughout India wherever this experiment was done. First of all there should be (a) Genetic Soil types on which the experiments had been conducted, (b) Daily rain fall and temperature humidity and other mateorological factors, (c) irrigation water supplies, quality of water, (d) Rise and fall of water table, and quality of ground water, (e) Crop yields and economics of cultivation expenses and net return to the cultivator, (f) incidence of weeds, insect pests and diseases. He thought that they should broaden the scope of the subject and make it applicable throughout India and future type of work should be taken into consideration as given in page 3 of the cyclostyled report.

Mr. Laksman Rao said that this subject of rotation of crops was said to be of limited importance as applying only to the Punjab and Sind but in his opinion it was applicable to South India also because hitherto in South India in the irrigation works it was only the heavy consumers like sugarcane and paddy which were the ruling crops under irrigation, thus consuming large quantity of water. With the limited supply of water it was possible to extend the benefit of irrigation only to a limited area up till now but now under the new reservoir scheme of Tungabhadra Valley and Lakkawali Reservoir, they proposed to extend the benefit of irrigation over a much wider area by not only having only sugarcane and rice but raising these heavy consumer crops with semi-irrigated crops year to year so as to get a much larger area under irrigation.

Dr. B. K. Mukherjee said that the terms of reference for this committee were rotation of crops which would give the best results in an irrigated intensity from 35 to 70 acres out of 100 acres. They had just been told that this was a subject having not much application for the whole of India and possibly this subject referred specifically to the Punjab, Sind or some portion of the U.P. He came from the U.P. and he happened to know the position there. He never came across any case of serious difficulty as regards what was explained as irrigation intensity. He did not think this problem had any great applicability to the conditions prevailing in the U.P. Of course, the subject as a whole was extremely interesting and they desired to evolve a system or systems of rotation which would be of great economic value to the cultivator would conserve moisture as far as possible in order to economise in the use of the irrigation supply available. He had not however been able to follow the report properly but from what Dr. Basu had just explained, it seemed that the Committee wished to place before the Board certain resolutions given on page 2. On item 1(d)—The rotation of crops which would give the best results in (i) *irrigation intensity of 25 to 70 acres in 100 acres and (ii) irrigation* intensity greater than 70 acres in 100 acres. He did not know of conditions elsewhere but as far as the U.P. was concerned he would like to assure that their irrigation intensity as a whole was greater than 70 in 100 acres although he was not aware of any actual experiment being done by the Irrigation Department in U.P. Dr. J. N. Mukherjee had pointed out that the aspect of procolation had been omitted. Something like 40—60 per cent. of water was lost in leading the water from the canal head to the fields. This was a very serious problem that must be taken into account. It was suggested that a soil survey of the tract should be done and that was a thing which should be done almost under every circumstances.

On page 3, at the bottom, under item (x) the Board was expected to suggest that 'there should be full coordination between irrigation and agricultural departments in these experiments. The notes of discussion contained tentative suggestions for cropping schemes under differing conditions of intensity and workers were to be invited to study these notes and the work done in (a) Lyallpur Farm in the Punjab (b) Sugarcane Research Station, Shahjahanpur, (c) Sugarcane Central Research Station, Pusa, Bihar. (d) Sugarcane Station, Padagaon, Bombay and (e) Agricultural Research Station, Siruguppa, Bellary District, Madras. He said that at Shahjahanpur they were carrying out very comprehensive experiments in regard to rotations as covered by item (x), *i.e.* 'With a view to study long term effects of crops in soils, experiments should cover at least rotational cycles, with all the crops of the rotational appearing in each year'. That was all being done and he did not quite understand what was meant by saying that workers might be invited to study the work which was being carried on in Lyallpur.

The Chairman said that the first point under this subject was the intensity aspect. If this was to be limited to 30 to 70, the scope of this subject would become very limited applying to two or three provinces only. If the intensity was to be taken at 100 or more, then the subject would have wider application and could be discussed by the Board. He wanted to know whether the idea of the Board was that the subject should be limited to the lower intensity or the scope should be enlarged.

Dr. Mukherjee said that the scope should be enlarged.

The Chairman said that if that was the idea, it would cover the whole of India. As had been explained, at present the Committee had not the relevent data before them and it had suggested that whatever data might be available, should be collected and placed before it to enable it to formulate its final recommendations.

Mr. Venkatachari said that since there was a lot of mis-conception as to the work done in this Committee he would like to point out that it was not that the Sub-Committee had no data at all. There were four papers on the subject, two from South India, one from Mysore and the fourth exclusively from the Punjab representative. He dealt with the cropping schemes which had been experimented in various provinces and gave a resume of the literature available. Much work had been done in some form or other in various provinces and it was felt that it should be carried out on some uniform lines and the future experiments should be so framed as to secure comparable results. The Committee was therefore, for an intensity of 30 to 70 acres. It was certainly limiting the scope of the work. If they extended it could cover the whole of India. One thing to be settled was whether they should start the scheme or not. The Committee's recommendation was that they should start it, and there was no difference of opinion about it. The second point was whether the lines of experiment should be laid down after studying the data available. The lines of experiment were not necessarily such that they should wait for the data available. He had indicated the lines which were very broad on which the workers could begin their work. It would not be right to lose a year or two. The feeling of the Committee had been that whatever inadequate data were available should be made use of and the existing Research organisations in the various provinces and states should be enlarged and expanded to the extent necessary and new organisations set up where none existed. At the end of two years, the data collected to be made available so that they might be able to make improvements.

Rai Bahadur Sawhney said that on Page 2 it was suggested that this subject be enlarged to include irrigation intensities greater than 70 acres per 100 acres. The resolution might therefore be worded as follows:—

Item I (d) The rotation of crops which will give the best results.

(i) Irrigation intensity of 25 to 70 acres in 100 acres.

(ii) Irrigation intensity greater than .70 acres in 100 acres.

"In regard to methods and scheme of experiments be read out the draft resolutions as given in Page 3 of the Sub-Committee proceedings and said that the work proposed to be done should determine the best rotation."

Amongst the recommendations made some dealt with the seasonal and climatic conditions, the irrigation supplies available in regard to the total volume and its seasonal and daily distribution, the conditions of water table and its relation to season and rainfall and irrigation sources and so on. Dozens of recommendations were made which might or might not be necessary for carrying out rotational experiments. He was definitely of the view that the only recommendation they could make was that in the absence of data this Board was not in a position to make any definite recommendations for best rotations with intensity of irrigation mentioned

in the subject. He was prepared to suggest something further and more concrete that if rotational experiments were to be carried out in future they should be more systematic and relevant data should be collected and soil survey carried out. It appeared to involve a very huge piece of work. It was a very complicated recommendation which he did not think they should make. This might be left to the Provinces and States concerned. If they wanted to carry out any experiments by themselves let them submit their proposals to the I.C.A.R. and ask for financial assistance. But the Board should not specify these 10 or 12 points for determining the best rotation.

The Chairman said that his idea was that if the Board accepted that they should not limit the scope to 30 to 70, it would be necessary to ensure that the work was done on a systematic basis. The question for consideration therefore was how this matter should be tackled and what should be the recommendations of the Board. His own idea was that the Board must give a lead.

Mr. Venkatachari said that the object in putting down specific suggestions was to help provinces and states in drawing up schemes or plans of work in this respect. The suggestions might be included in some sort of a circular from the Indian Council of Agricultural Research saying that data on these lines would have to be made available before a scheme could be approved. If they had a full picture of what the Irrigation Department wanted they should be able to arrive at a system of rotation of crops as quickly as possible in accordance with local conditions. He believed that it would be better to send out these recommendations because the workers in the field would find some sort of help in laying out their schemes of experiments. But he was not very particular that the suggestion should go as resolutions.

The Chairman said that it appeared that the Board agreed that the intensity should not be limited and that work on this line should be done. He thought the best way would be to pass a resolution to that effect. The I.C.A.R. would then examine it and send a circular inviting the provinces and states to put up schemes on these lines. Mr. Venkatachari enquired what would be the position of a Province which took up the work without the help of the Indian Council of Agricultural Research. The Chairman said that they would be welcome to follow such course as they might decide to adopt.

Mr. Venkatachari desired that the proceedings should record this fact. This was agreed to.

The Chairman said that the Board might pass a resolution that this work was necessary and should not be restricted to the lower intensity and the Indian Council of Agricultural Research should ask the Provinces and States to send up schemes if they desired. All these discussion and recommendations might however be recorded in the proceedings.

The Board approved of the suggestion. The following resolutions was then adopted:—

"The Board while endorsing the suggestions contained in the recommendation of the committee under item I(d) (*vide* appendix VII) recommends (i) that the scope of the subject should

be enlarged to include irrigation intensities greater than 70 per cent. per 100 acres so that instead of a limited applicability it might cover ranges upto 100 per cent. and the recommendations are made sufficiently wide to cover other areas.

(ii) that work on the lines proposed is necessary and that the recommendation of the committee as well as copy of this resolution be circulated to the Provinces and States who would be welcome to submit schemes of research on these aspects to the I.C.A.R. for consideration."

After the business was over, the Chairman thanked the members and others for their cooperation and sincere help which enabled him to finish the present important and lengthy season within time. The subjects which were discussed were not only very important but were of such a nature that they could be discussed for days together. He was sure the members welcomed this opportunity to have their views on different matters exchanged.

He was very grateful to the members and visitors to the meeting and especially to the Honourable Ministers whose presence at the meeting was a source of encouragement. He also appreciated the good work done by the staff and the excellent cooperation received from the provincial Government.

The meeting then terminated with a vote of thanks to the Chair.

REPORTS OF SUB-COMMITTEES

SUBJECT No. 1.

The need for breeding crop varieties adapted to varying levels of soil fertility and for special conditions of soil and climate.

The following were present.

1. Dr. J. N. Mukherjee,—*Chairman.*
2. Sri M. Ananthan.
3. Rai Bahadur P. Venkataramiah.
4. Dr. J. A. Daji.
5. Mr. E. A. R. Banerjee.
6. Dr. B. K. Mukherjee.
7. Mr. P. M. Ganguli.
8. Dr. D. V. Bal.
9. Dr. T. Sadasivan.
10. Mr. C. Ramaswamy Naidu.
11. Dr. R. V. Tamhane.
12. Dr. W. V. B. Sundra Rao.
13. Mr. I. Chatterjee.
14. Dr. B. P. Pal.
15. Dr. N. Parthasarthy.
16. Capt. V. M. Chavan.
17. Mr. R. Balasubrahmanyam.
18. Mr. M. B. V. Narasingarao.
19. Mr. C. M. John.
20. Mr. T. K. Balaji Rao.
21. Mr. A. B. H. Khoorshid.
22. Dr. P. Parija.
23. Mr. P. D. Karunkar.
24. Dr. P. Krishna Rao.
25. Dr. B. C. Kundu.
26. Mr. Khagendranath Kakoti.
27. Mr. S. N. Venkataramana Ayyar.

SUBJECT 1(a).

The infomation given in these notes and the discussions at the meeting brought out clearly that it is essential in plant breeding experiments and trials of newly evolved material to consider in detail the various environmental conditions under which the varieties will be actually grown. Crop yield is the measure of the response of the crop to the interaction of environmental factors on its genetic make-up. Breeders have no doubt generally recognised the limitations of climate and soil and the selection of plants from local varieties or hybrid populations is carried out in representative climatic and soil regions. However, such selections and tests for yield have been and on the whole still are being carried out at one level of soil fertility which is believed to be characteristic of the locality or region concerned but it is seldom well-defined. Further, although newly evolved material is at present tried at different centres in various regions, the soil characteristics of the region and in particular of the experimental fields are quite often not determined. From the report of the All India Soil Survey scheme it may be seen that not less than 21 regions can be distinguished on the basis of broad differences in soil and climatic conditions. Another aspect of the environmental conditions which is of no less signficance in varietal trials is that most crops have to be grown both under rain-fed and irrigated conditions. It is thus necessary to test the response of varieties also to these two conditions. The other features of environmental conditions which require consideration in detail are the differential responses of varieties to levels of fertility of the same soil type. Experiments carried out in India and abroad indicate that not only do varieties respond differently to various fertility levels of a soil type but the responses may be so distinct in some cases that there is a reversal of the order of performance of the varieties. Thus some varieties have been found to yield relatively higher on well fertilised plots while others were more productive on low fertility plots. Consequently, some of the prominent workers in this field have definitely recommended that not only should variety trials be conducted on sites representative of the different soil types, but experimenters should also adopt generally the practice of including at least two levels (average and high) of framing from the initial to final stages of selection.

If we are to produce more food which is urgently required, this can be done chiefly by increasing the acre yield of our crop plants as not much new land is available for cultivation. Acre yields, however, can be increased only by improving the soil productivity by proper crop rotation, manuring, irrigation etc., and by growing suitable varieties that will respond to high level farming. Special attention, should, therefore be given to breed varieties suited to these conditions. On the other hand conditions of high level farming do not actually obtain in the major portion of our arable land. It is thus necessary to consider whether it is likely that such an improvement in farming conditions would take place in the near future to justify the target which had been suggested for breeding. The Committee came to the conclusion that plant breeders should take into account the actual levels of fertility under which the

varieties which they are breeding would be ultimately grown. In any region, however, there are areas with both high and low fertility ; also there are farmers who can afford to manure their land quite intensively and others who are not in a position to do so. The object the committee have in view is, therefore, not to restrict breeding only to high levels of fertility, but to extend the present practice which embraces only one level of fertility to more levels in order to enable the farmer to get the best out of his land wherever he is in a position to adopt high levels of farming.

The Committee recognize that the position may vary as regards different crops and in some, *e.g.*, cotton, practical difficulties might be encountered ; but the need for breeding varieties suited to high level farming conditions should not be lost sight of. In contrast to cotton, however, millets are less cosmopolitan and more conservative than other crops ; and here the need is all the greater to fit the variety to the soil type.

The Committee would also emphasise the desirability of studying differences in the physiological behaviour of varieties. In illustration, they would record that in Madras indications have been obtained that duration of a variety of paddy seems to be correlated with its yield.

The Committee have to emphasise the necessity for testing newly evolved plant material in the initial stages under as wide a range of the environmental conditions enumerated above as is feasible. They also emphasise the desirability of starting the work with a sufficiently wide range of material. If facilities for testing plant material in the initial stages are not made available, there is the definite possibility of eliminating valuable plant material (genotypes) which might be better suited for one or more of the specific environmental conditions discussed in this report.

The Committee next considered the facilities which should be made available to the plant breeder for carrying out the recommendations of the Committee. It is obvious that in order to avoid the elimination of promising material which might suit one or other set of environmental conditions the plant breeder should be enabled to try out the newly evolved material he has obtained under as wide a range of conditions as is likely to occur in actual practice. For this purpose, an experimental station should be located in each of the regions determined by broad differences in soils and climate and such existing experimental stations as are found suitable for this purpose should be adequately equipped and staffed without delay wherever necessary. In those regions where such stations do not already exist ; steps should be taken to establish them as early as possible. The Committee are definitely of opinion that both in the interest of economy and scientific efficiency, the experimental stations in each such region should be the centres of all experimental work on soils and crops pertaining to the region and these stations should be used both by the Central and Provincial Agricultural Research Institutions in mutual cooperation,

Such an arrangement will not only secure better team work and co-ordination of work on soils and crops but will also enable the plant breeders working on any particular crop to test the potentialities of the material evolved by each of them in all regions of significance to the breeding work in hand.

The Committee desire to invite the attention of the Board to the recommendations of Dr. A. B. Stewart to lay down an experimental block at the disposal of the plant breeder for varietal trials in selected centres and recommend that such blocks with known soil characteristics should be provided in all sub-stations or farms wherever feasible.

The Committee also recommend to the Board that a rapid r connaissance soil survey should be carried out in provinces and states without delay in order to demarcate more clearly the different soil and climatic regions and that provincial and state chemical laboratories under the Departments of Agriculture should be properly staffed and equipped for carrying out the soil investigations required in connection with varietal trials.

In conclusion, the Committee recommend the following resolutions for the approval of the Board :—

(1) That the plant breeder should keep in view ;

(a) that the variety has to be fitted,

(i) to the different regions which can be distinguished on the basis of considerations of broad differences in soil and climate and in particular to each soil type ;

(ii) to rain-fed and to irrigated conditions ; and

(iii) to the different levels of fertility as obtain under average and high farming conditions; and

(b) that the selected variety should also have power of resistance to adverse conditions, such as drought, frost and pests and diseases.

(2) That experimental stations be established in each of the regions mentioned above and that arrangements be made also for testing varieties in selected substations or farms in each such region.

(3) That adequate facilities of staff and equipment for the investigations enumerated in item (i)(a) and (b) above as also for the necessary soil investigations, be provided.

(4) That a rapid reconnaissance soil survey be undertaken for each province and state.

SUBJECT No. 1(b).

The Committee reviewed the work done on the maintenance of soil fertility in India as described in the above notes, and supplemented by statements made in the meeting. They were of opinion that in order that systems of correlated soil and crop management can be evolved which will build up and maintain soil fertility it is essential that the innate characteristics of land and its topographical features should be taken into consideration. The suitability of land for growing crops or trees or for pastures should be determined and a land use classification made accordingly. It is obvious that it is not possible to maintain soil fertility if a soil is put to a use for which it is not really suited. Agricultural practices in India as also experimental investigations here and elsewhere have definitely established that legumes (and also grasses) play a very important role in building up soil fertility. The need for the evolution of suitable crop rotations in which legumes are included, to suit the different soil climatic regions and the cropping systems, by trying indigenous and exotic types of legumes, is clearly established. Also, the application of phosphatic fertilizers to legumes is known to build up speedily soil fertility and increase the yields of crops. In selecting legumes, their usefulness as fodder, as cash crops, catch crops and cover crops or for inclusion in mixed cropping systems, should be taken into consideration. In such studies of crop rotations the overall yields and economics of the entire rotation should be kept in view.

In working out manurial schedules necessary for the maintenance of soil fertility it is essential that irrigated and rain-fed areas should be considered separately, taking into account the soil and climatic characteristics. Green manures have not only been used in India for a long time, but have also been found as a result of experimental investigations to be of great importance in maintaining soil fertility. Farmyard manure and compost too have also been found to be of great value. Varying results have however been obtained showing differences between these organic manures as regards their influences on soil productivity. The Committee, therefore, recommend that more extensive investigations should be carried out on the effect of these manures on soil productivity.

Similarly, it is necessary to study in detail in manurial experiments the effect of different forms of nitrogenous and phosphatic fertilizers in relation not only to their effect on soil productivity but also in relation to the question of estimating the requirements of fertilizers with a view to their manufacture, procurement and supply.

Better results have often been observed by the use of artificials in conjunction wth organic manures, but, organic manures, are not available in sufficient quantities. It is consequently necessary to carry out more thorough investigations on the use of artificials either alone or in conjunction with organic manures. While a response to treatment with N has been observed more generally, response to nitrogenous and phosphatic fertilizers used in conjunction has also been significant in many instances. The Committee, therefore, recommend that more systematic

comparisons should be made of the effects of treatment with N, NP, and NPK on different levels, Two other subjects which the Committee consider worthy of thorough investigation are,

(a) the fixation of phosphates, and

(b) placement of fertilizers, specially of phosphatic fertilizers.

Since soil organic matter plays an important role in soil fertility by building up a desirable soil structure and promoting microbiological activity more attention should be paid to investigations concerning it.

Detailed studies of soil microorganisms are also needed and in this connection the role of Azotobacter in contributing to soil fertility is worthy of special attention.

Regarding quality in crops, the Committee were of opinion that since the expression 'quality' is often ill-defined and connotes a variety of characteristics in different crops, extensive and systematic investigations are necessary,

(a) to define quality, and

(b) to correlate it with the results of manurial treatments.

The discussion in the committee was mainly restricted to the nutritive quality of crops including fodder crops in so far as it is determined by the major chemical constituents which are capable of estimation without costly equipment. Systematic chemical analysis of crops and fodder should be done but where facilities are lacking at present, at least chemical estimations of N, P, K, Ca, ash, and carbohydrates should be made. The importance of determining the nature and content of vitamins and of micronutrient elements in relation both to human and animal nutrition is obvious. The Committee, therefore, recommend that the main experimental station in each province or state should be adequately equipped in order that thorough investigations on the nutritive value of selected crops can be carried out. The Committee also recommend that biological assay of the nutritive value of crops by experiments with animals be carried out in the main stations in conjunction with biochemical departments of universities and other institutions.

The Committee would like to emphasise that in order that the investigations suggested above can be carried out satisfactorily, a rapid reconnaissance suvey on the lines indicated in the resolutions of the Soils and Crops Wing of the Board of Agriculture in 1935 be carried out immediately ; and that the recommendations made by Dr. A. B. Stewart as regards soil studies and agronomic experiments should be implemented as early as possible. They, therefore, reiterate the resolutions regarding soil survey and soil studies made under item 1(a).

The Committee feel that experimental results obtained in the various stations will scarcely have any appreciable effect on increased crop production unless definite measures are taken by Government for the manufacture, procurement and supply of the manures and fertilizers in required quantities. They further recommend that special steps should be taken to arrange for the supply of seeds of green manures, of proved value, to peasants ; to encourage the utilisation within the country of

indigenous manures and fertilizers such as oilcake, bone, horn and hoof and to prevent the export of these.

In conclusion, the Committee make the following recommendations for the approval of the Board :

(1) That a land use classification should be carried out to determine what areas are suitable for growing crops or trees or for pastures.

(2) That suitable crop rotations in which legumes that build up soil fertility are included should be evolved to fit the different soil climatic regions and cropping systems. Both indigenous and exotic legumes should be studied ; their usefulness as cash, catch, cover, or fodder crops, or for inclusion in mixed farming being taken into consideration.

(3) That manurial schedules for the maintenance of soil fertility should be worked out, treating irrigated and rain-fed areas separately. The different forms of nitrogenous and phosphatic manures should be studied in detail. Also, in manurial experiments a comparison should be made of N, NP, NPK treatments at diffeent levels. The fixation of phosphates and placement of fertilizers especially phosphatic fertilizers should also be investigated.

(4) That more systematic investigations should be carried out with different forms of organic manures especially green manures, farmyard manure and compost either alone or in conjunction with artificials.

(5) That soil organic matter should form an important subject of investigation speially in relation to its effect on soil structure and on microbiological activity.

(6) That microbiological investigations should be given more importance and attention should be paid in this connection to the role of Azotobacter in soil fertility.

(7) That in relation to nutritive quality of crops, systematic chemical analyses should be done. Where facilities are lacking at present, at least N, P, K, Ca, ash and carbohydrates should be estimated. The main experimental stations in each province or state should be fully equipped to carry out comprehensive investigations on the nutritive value of selected crops. Biological assay of nutritive value of crops should be carried out in conjunction with biochemistry departments of universities or other institutions.

(8) That a rapid reconnaissance soil survey should be immediately carried out in each province and state on the lines indicated in the resolution of the Crops and Soils Wing of the Board of Agriculture in 1935. The recommendations made by Dr. A. B. Stewart as regards soil and agronomic studies should be implemented as early as possible.

J. N. MUKHERJEE,
Chairman.

SUBJECT No. 2

The importance of rootstocks in the standardisation of fruit tree material

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The following were present :

1. Dr. G. S. Cheema—*Chairman.*
2. Mr. B. M. Mitra.
3. Mr. Rana Surat Singh.
4. Mr. Mohibullah.
5. Mr. J. D. Manning.
6. Dr. Syedudin Swallhay.
7. Mr. Jagdish Chandra.
8. Mr. Brij Mohan Panda (afternoon).
9. Mr. Jabir A. Ali.
10. Mr. B. S. Varadarajan.
11. Mr. K. C. Naik—*Technical Secretary.*

After consideration of the subject in all its aspects, the Committee summed up the discussion as under :—

(1) Standardisation of the tree material is of paramount importance for successful fruit production, since it means uniformity of the performance in the orchard and consequently very high orchard efficiency. The achievement of this objective depends not only on tree and bud selection among acclimatised varieties, so as to secure efficient clonal strains, but also the raising of scion trees on homogeneous and least variable rootstock material of proven value.

(2) In respect of commercial fruits of the Union, the problem of standardisation and of rootstocks are of special importance for the present in mangoes, cytrus and certain deciduous fruits.

(a) In mangoes trial of polymbryonic rootstocks, rootgrafts and double worked plants for each of the leading commercial mango varieties in the typical mango areas of the country appear necessary, along with the selection of trees in each scion for inherently high and regular cropping tendencies. This combined project is aimed to produce a rootstock-scion (stionic) combination which should prove an efficient orchard entity for each region.

(b) Citrus rootstock trials are required to be planned on a country wide basis, to secure efficient stionic combinations for each of our major citrus varieties.

(c) For deciduous fruits also similar trials, wherein standardised clonal root-stocks like the Millings and Mortons for apples, may be included.

(3) Co-ordination of the trials will be facilitated if the provinces and States initially plan the trials for their optimum fruit zones, for subsequent scrutiny and sanction by the Indian Council of Agricultural Research.

The Committee while recognising the supreme importance of standardised material in raising profitable orchards, resolved that (1) Towards this end, work be planned in several directions. This would involve firstly, the selection of trees in acclamatized varieties on the basis of actual orchard performance and secondly, the selection of bud in order to eliminate off types from future orchards. These have to be supplemented by the determination of an optimum stionic combination for each important region and in respect of each major cultivated fruits. The provinces and states may therefore plan comperhensive trials to cater for each of the major areas, and these schemes may later be scrutinised by the Centre. In the case of other fruits, wherein root-stocks are considered to be of no significance, standardization will naturally be effected through only plant selection, supplemented by careful roguing out of variants in nursery stage.

(2) As a direct means of help to the fruit growing industry, and pending the results of trials suggested above, an effective means be devised to provide efficient and standardised material for the new plantings as well as to fill the gaps in the existing orchards. Such an objective can be achieved through the regulation of the private fruite nursery trade as well as by concerted propaganda by trained horticultural workers on the basis of available knowledge.

(3) In this connection, registration of fruit nurseries should be deemed as a work of urgent importance since on this depends the supply of reliable plants of intrinsically high performance.

G. S. CHEEMA,

Chairman.—7-4-48

SUBJECT No. 3.

"Cereal Rusts".

The following were present :—

1. R. B. R. L. Sethi—*Chairman.*
2. R. B. Kalidas Sawhney.
3. Mr. G. S. Kulkarni.
4. Mr. J. L. Mehr.
5. Mr. D. Varadarajan.
6. Mr. M. Kantiraj.
7. Mr. R. B. Ekbote.
8. Dr. B. B. Mundkur—*Secretary.*

The Chairman gave a short history of the work on cereal rusts done in India upto the present time. All the three rusts namely, black, brown and yellow occur in India and work on them has been in progress for several years. In 1946-47, there was a severe epidemic of black rust in Peninsular and Central India which caused an estimated loss of nearly two million tons of wheat. In some provinces the incidence was so great that there was not even enough seed left for the subsequent year. In C.P., for example, the Government had imported 40,000 tons of wheat for distribution among the cultivators for sowing. The situation had become so serious that three meetings were called by the Government of India and held at Delhi to consider measures to control this disease which was causing so much havoc, and finally the Government of India appointed a special Wheat Rust Control Committee consisting of Mr. D. R. Sethi. Dr. H. S. Pruthi, Dr. J. N. Mukherjee with R. B., R. L. Sethi as the convener. At the meetings of this Committee to which Mycologists from concerned provinces were also invited and in which they participated the problem was discussed from various points of view and it was agreed that Dr. Mehta's scheme for suspension of summer Wheat cultivation in the Nilgiris and Pulney hills in the Madras Presidency, in the Hassan and other districts in Mysore and Dharwar and Belgaum districts in the Bombay Province, should be approved and summer wheat cultivation in these areas be legislation. The Chairman also stated that the Government of India had already been approached to sanction the scheme as soon as possible.

Mr. Ekbote informed the Committee that during that past six years three new races of rust had appeared in C.P. and two bio-types in Mahableshwar and suggested that more intensive work on the study of physiologic races was essential. He also stated that specimens of *Berberis asiatica* had been found growing near Pachmari and that specimens had been sent to Dr. Mehta for testing the part played by the plant, if any, as an alternate host. In insisting on the need for more extensive breeding work he mentioned that in Western Canada alone over two million dollars had been spent on similar work and that good resistant varieties had been devolped as a result of these investigations—In India only a fringee of problem was touched yet and for full investigations suffi eient amount of funds and other facilities should be provided at an early date.

Mr. Kulkarni enquired as to what exact type of work will be required to be done in rust nurseries and whether such nurseries would have to be maintained during off-season also. He was informed that these nurseries would be set up during the wheat growing seasons with materials that would be supplied by the I.A.R.I. He also expressed the opinion that the breeding of rust resistant varieties should not only be confined to the five zones recommended by the Wheat Rust Control Committee, but it should also be carried out in other areas where growing of wheat was of importance.

Mr. Varudarajan referring to Dr. Mehta's recommendation for the legal prohibition of growing of summer wheat in Nilgiris and other adjacent tracts said that the experiment of prohibiting the cultivation of summer wheat had already been tried for a period of two years but without any effective results, and expressed the view that continuing the experiment for one year more would perhaps meet the case and that Dr. Mehta should be in entire charge of the work.

He also suggested that a certain amount of fundamental work should be done to assess the damage done by rusts to other cereals such as *sorghum, bajra* and *setaria etc.*

R. B. Kalidas Sawhney while endorsing the need for intensification of breeding work for the production of rust resistant varieties suggested that an expedition of two or three wheat research workers may be sent to a few selected countries for the collection of rust resistant and other breeding material which may be of genetic interest.

The Committee then made the following recommendations:

1. *Fundamental Research.*

(i) The Committee desired that intensive work on physiological races, their origin etc., should be done. It did not feel justified in the statement made in one of the papers that there were and would be only a few races of rust in India as that was not borne out by facts. The appearance of three new races in C.P. (34, A, B) and two in Mahableshwar (42, A & B Bio-types) in the course of a few years indicated that there may be more races already existing or would arise by mutation or other means.

(ii) The rusts of millets like *sorghum, bajra* and *setaria* should be further investigated, their life histories the damage they cause etc., should be found, before anything further can be recommended about them.

2. *Control.*

(i) The scheme for suspending wheat cultivation in summer in parts of Peninsular India as recommended by Dr. Mehta and approved by the Wheat Rust Control Committee should be sanctioned and Dr. Mehta should be closely associated with this work to ensure that it is carried out to his satisfaction.

(ii) The plan of dusting sulphur as a fungicide against wheat rust should not only be carried out but certain other fungicides like sodium silicio fluoride etc., should also be tested.

(iii) The Committee endorsed the proposal made by Dr. Mundkur in his paper, that in each province and Sate there should be at least 200 dusting machines and 20 to 30 tons of sulphur dust in reserve for use against rust whenever epidemics are apprehended in order to save at least some wheat for seed purposes.

(iv) The Committee recommended that work on breeding should be intensified and more funds should be placed at the disposal of the Provincial and State Governments in order to do this work in a more efficient and intensive manner and as many breeding stations as possible to meet the requirements of the different wheat growing provinces and States should be opened and placed in charge of breeders specially appointed for this purpose. Large sums have been spent by other countries on this work, Canada having spent two million dollars in Western Canada alone over a period of 28 years for such investigation.

(v) The Committee recommended that an expedition consisting of two or three wheat investigators should be sent abroad for the collection of wheats resistant torusts and other fungus diseases and which may be useful for genetic purposes also.

3. *Agronomic work.*

(i) The Committee agreed that in order to take prophylactic measures in time, weekly records on temperature, rainfall and humidity should be analysed and co-related with rust incidence and wheat yields in as many places as possible in the wheat growing regions. Past data, wherever available, may also be analysed.

(ii) Assessment of losses due to wheat rust should be determined in all wheat growing regions. The work on alternate and collateral hosts needed further investigation as also the precise method of dissemination of rust. The variety *Beri-beri asiatica* which has not been tested for its susceptibility to wheat rust should be tested by Dr. Mehta and also at the I.A.R.I.

(iii) The Committee was not hopeful of success of mixed croppings but agreed that the cultivation of early and semi-resistant varieties should be encouraged as that would help in reducing losses by rust.

(iv) The Committee noted with satisfaction the work on inter-generic and inter-specific that is being carried out at the I.A.R.I. Although this has not so far led to much success, the Committee felt that the work should be continued with a view to explore the further possibility of achieving the desired results.

R. L. SETHI,
Chairman—8-4-48.

SUBJECT No. 4.

Review of the comparative merits of different methods of improved farming practised in the country such as co-operative farming, collective farming consolidated farming, joint management, consolidation of holdings etc., with particular reference to improvement in the yield of crops and economic condition of cultivators.

The following were present :

1. Lt. Col. C. A. MacLean—*Chairman.*
2. Mr. K. C. Chetty—*Technical Secretary.*
3. Mr. C. C. Taylor.
4. Dr. T. G. Shirname.
5. Mr. K. Gopalan.
6. Dr. B. G. Kundu.
7. Mr. S. C. Roy.
8. Mr. M. C. Joshi.
9. Mr. P. D. Nair.
10. Mr. N. J. Deshmukh.
11. Mr. B. Nataranjan.
12. Mr. K. C. Ramakrishnan.
13. Mr. Jabir A. Ali.
14. Mr. S. N. Venkatraman.
15. Mr. Narasimha Raju.
16. Mr. Raghotham Reddy.
17. Mr. Mohibullah.
18. Rai Bahadur Kalidas Sawhney.
19. Dr. T. G. Menon.
20. Mr. Khoorshid.

1. Mr. MacLean, Commissioner of Agriculture, Baroda gave a very brief resume of the work being done in Baroda State by way of studying different forms of tenure and management *viz.*, peasant proprietorship, tenant farming, co-operative farming, and collective farming. Although the scheme had been functioning for only a year it was already patent that the owner-occupier was the more industrious and though his actual standard of farming was not higher than that of the tenant farmer, he did give more attention to the improvement of his holding. So far, collective and co-operative farming had not appealed to those engaged on them ; every family strongly desired its own plot of land ; and the standard of work was not so high as in the two former systems. Apart from this, petty pilfering of the crop, belonging to the community, was a common failing.

2. Dr. Shirname, Agricultural Marketing Adviser, gave an interesting account of the various system of co-operative farming Palestine, and was of opinion that the system of farming by small holders' co-operative farms as worked with such conspicuous success in that country might be tried in India on an experimental basis.

3. Details of the different systems of settlement of landless labourers in the Madras Presidency with co-operative farming as an ideal, but not yet practised, were given by professor Ramakrishnan, Lecturer in Agricultural Economics, Coimbatore.

4. Mr. Nair, Director of Agriculture, Central Provinces, described what had been achieved by consolidation of holdings in that Province. He nerated the many beneficial results, emanating from the movement, which had now reached a stage where demands for consolidation came spontaneously from cultivators themselves.

5. Rai Bahadur Kali Dass Sawhney, Director of Agriculture, Hyderabad, described the scheme of Joint Stock Farming as practised with such outstanding success in the Sudan, and he felt that it was one which, with suitable modifications might well be tried in India, wherever any large new Government ventures are being inaugurated.

6. In the discussion which followed, the merits of peasant proprietorship were generally recognised, but in view of the diverse economic and social factors prevailing throughout India, the Committee did not feel that it would be possible to lay down a hard and fast solution for the whole of the country. Pilot schemes were, therefore considered essential, and as a part of such a forward policy it was necessary to embark on a determined programme for the consolidation of holdings. It also emerged from the discussion that a good deal of confusion was prevalent regarding the exact connotation of different terms used in connection with various kinds of co-operative farming. The Committee was, therefore, of opinion that those terms in general use should be clearly and unequivocally defined.

7. The following resolutions were then passed by the Committee :—

1. That, with a view to improving the social and economic condition of the cultivators, a Special Officer should be appointed by the Central Government to prepare, in consultation with Provincial and State authorities pilot schemes of different systems of farming, such as co-operative farming, collective farming, joint farming, joint stock farming, suitable to the various conditions prevailing in different tracts of India.

2. That the Officer appointed should do his utmost to see that effect is given to these pilot schemes as quickly as possible by Provincial and State authorities.

3. That the Officer appointed should describe in collaboration with recognised experts the nature and scope of such systems as,

co-operative farming, collective farming, joint farming, joint stock farming and community farming etc., and submit his views to the Government of India for final approval.

4. That in view of the imminent revision in the prevailing land systems in certain parts of India, a measure of priority should be given to those proposals.

5. That a comprehensive programme of consolidation is vital to agricultural rehabilitation and that the State should not hesitate to exercise a large measure of compulsion in this sphere and that commensurate with the progress of consolidation, there should be development of industries, not only in the industrial areas but in the villages as well.

SUBJECT No. 5.

Consequent on the devision of the country to consider measures to be taken from the short range and long range point of view to maximise the production of food particularly of cereals in India so as to reduce her dependence on imports to the maximum extent possible and to suggest five year targets of increase in such production for each unit of administration comprising India.

The following were present :—

1. Mr. M. S. Sivaraman—*Chairman*.
2. Mr. R. D. Bose—*Technical Secretary*.
3. Dr. H. S. Pruthi.
4. Sardar Bahadur Lal Singh.
5. Sardar Bahadur Harchand Singh.
6. Mr. M. C. Cherian.
7. Mr. V. S. Hejmadi.
8. Mr. V. N. Likhite.
9. Mr. T. C. K. Pillai.
10. Mr. M. Abdul Majid.
11. Mr. S. Ramachandran.
12. Mr. R. P. Padhi.
13. Banamali Patnaik.
14. Janab Md. Zafar Ali Khan.
15. Mr. M. Sankara Menon.
16. Dr. L. C. Sikka.
17. Mr. B. C. Kundu.
18. Mr. B. S. Varadarajan.
19. Director of Agriculture, Cochin.

The Chairman introduced the subject by stating that though some stress has been laid on the division of the country, the food problem in India had been chronic even before this division and that in considering any question of increasing food production from the long or short term points of view, our aim should be not merely to improve the production of cereals but also to devise ways and means of producing a balanced abundance needed for a proper standard of nutrition for a growing population. He stated that the best economic utilization of every unit of land should be our goal and maximisation of food production is possible, by

(i) bringing the area which is now lying waste under the plough, and

(ii) increasing the yield per acre of all cultivated lands so as to improve the production of cereals, pulses, fruits and vegetables, fats and oils, milk, eggs and other animal products.

Sardar Bahadur Lal Singh endorsed the views expressed by the Chairman and stated that in the long run we should not lay undue emphasis on increasing the production of cereals but should stress the need to grow other food stuffs like pulses, potatoes, bananas, pine-apples papayas etc., which give more food per acre. Mr. Lal Singh opined that the whole notion of the agricultural development in this country needs a radical change and that compulsion by legislation should be resorted to in order to effect rapid improvement.

Sardar Bahadur Harchand Singh stressed the fact that if more food is to be produced the cultivator should be assured of a proper price.

There was a great deal of discussion on this subject in which Dr. Pruthi, Sardar Bahadur Harchand Singh, Mr. Likhite, Mr. Cherian, Dr. Kundu and many other members took part.

In a note submitted for the consideration of the Committee Col. Maclean endorsed the following sub divisions of long-range and short-range measures suggested in Sir B. Nanavati's book on 'Indian Rural Problem'.

Long-range.

(a) Increase of industrialisation.

(b) Increase of Irrigation facilities.

(c) Improvement of Agricultural finance and marketing.

(d) Reform of the land tenure system.

(e) Consolidation of holdings.

Short-range.

(a) Encouragement in the composting of all manner of organic wastes.

(b) Supply of fortilisers and cakes.

(c) Supply of good seeds.

(d) Provision of good implements.

(e) Improvement of village herds.

(f) Discouragement of certain forms of cropping ; cotton—jowar for instance,

(g) Adoption of simple soil conservation methods.

The Committee felt that though some of the measures are capable of execution a short period no hard and fast line of classification of long and short term measures is feasible in all cases and was further of the view that it should confine its recommendations to matters of a purely agricultural nature.

The Committee considered that the measures already recommended by the Board in 1945 to maximise the production of food in the Grow More Food Campaign could bring about the expected results if these are fully implemented and that the final results would necessarily be to reduce India's dependance on imports of food grains. The committee therefore felt that the Board might lay special emphasis on the following measures.

I. Land Utilisation.

(i) The Provincial and Regional Boards for land utilisation should be set up without further delay.

(ii) These Boards should undertake a broad and rapid survey of the waste lands in their jurisdiction, and classify these lands according to their possible use. The Boards should also undertake a survey of sub-marginal lands with a view to retire such of these lands from agriculture as could be put to more profitable uses.

(iii) The Provincial Land Utilisation Boards should be given executive power to carry out the plans made by them and approved by Government.

(iv) Government should have the right to acquire, lease or re-assign all cultivable lands that have not been actually cultivated for three years or more, for no valid reason.

(v) Private enterprise should be encouraged on a large scale by the grant of a long term leases and by subsidising the purchase of necessary machinery and equipment required for reclamation and provision of irrigation.

II. Improvement of water supplies by irrigation and other means.

The Committee suggests that the Board might reiterate its previous recommendations, *viz.*

(i) the continuation of the emergency measures now in force with regard to

(a) Minor irrigation projects ;

(b) Conservation of rainfall by embankments ;

(c) Contour bunding ;

(d) Drainage of wet land ;

(e) Better utilisation on canal water ;

(f) Pumping water from deep rivers ;

(g) Pumping water from sub-soil reservoirs ;

(h) Sinking and improvement of wells on cultivators' holdings.

with the financial assistance from the Centre for a period of another five years, in view of the difficult food situation prevailing in the country.

(ii) Contour bunding, exploration of sub-soil water and the sinking and improvement of wells should be continued afterwards as a permanent policy by Provincial and State Governments ;

(iii) Where the execution of irrigation and other works mentioned above is held up for lack of qualified personnel, every possible step (*e.g.*, offering more attractive scales of pay) should be taken to recruit such personnel ;

(iv) Measures should be taken to ensure better distribution of existing supplies of canal water, care being taken that on the extension of canals the cultivators in the previously commanded area would not suffer ;

(v) The grant of Taccavi on a liberal scale for the construction of wells on cultivators' holdings should be given. Where the small holders have not enough security to secure an adequate amount of Taccavi loan, the State should construct the wells and charge for the water used or recover the cost of the construction in easy instalments.

In addition, the Board might emphasise :

(i) that Government should provide for every area needing them, units of mechanical exacavators, power drills, air compressors etc., such as were used by the Military during the war.

(ii) that arrangements should be made by Government for larger supplies of small pumping sets to the cultivators.

(iii) that the Government should provide better facilities and grant high priorities for the supply of coal, cement, bricks etc., required for the construction of wells.

(iv) that Bund formers should be made available in larger numbers to villagers for mechanically bunding their dry fields.

(v) that the construction of wells should be particularly encouraged in delta areas in order to ensure early sowing of paddy

nurseries and early transplanting, as it has been proved that early planting results in higher yields.

(vi) that subsidies should be granted for the excavation of small ponds not exceeding ten cents in paddy lands with a view (1) to rear fish (2) to raise the level of the surrounding area to help production of fodder and vegetables and (3) to help to raise nurseries in time.

(vii) that a survey of the subterranean resources should be made and steps taken to augment the subterranean supplies by methods such as afforestation of sloping terrain, surface reservoirs, recharge, wells sub surface dams etc., before any projects of large sinking of wells in provinces other than the East Punjab, United Provinces and Bihar are under taken.

III. Manures and Fertilisers.

The Board might reiterate its previous recommendations :—

(i) that the assistance given by the Government of India to encourage the greater utilisation of manures should be continued.

(ii) that continued assistance from the Central Government is necessary for conversion of town refuse into manure and manufacture of village composts till it becomes an established practice and for stimulating their utilisation.

The Committee feels that no great progress has been made in some provinces in the matter of production of composts from the waste products of urban areas and recommends that the making of composts should be made obligatory in cities and municipalities and wherever organised panchayats exist.

The Board might also recommend.

(i) that adequate provision should be made for the supply of Sulphate of Ammonia, Superphosphate, flour phosphate, Bone-meal etc., and that the question of utilisation of Trichy phosphates for the benefit of the cultivators should be considered actively.

(ii) that greater stress should be laid on the more intensive use of organic manures such as Farm Yard Manure, composts, oil cakes, of green leaves and all waste products of agriculture. In this connection the possibilities of growing quick growing leavy shrubs like Glyricidia maculata and of plants that are not growsed by goats like Galatropis, Adathoda vasica, wild sunflower etc., on all waste lands, canal and tank bunds, sides of roads and railway tracks and on any place which is not put to more profitable use should be brought home to every cultivator

(iii) that in order to conserve large supplies of Farm Yard Manure some of which is now being used as fuel, active measures should be taken for raising quick growing fuel trees such as *Casurina, Accacia, peins, Prosopis juliflora, Leucauna glauca* etc., on sub marginal lands between villages on canal bunds and tank beds, on sides of roads and railway tracks and for this purpose, subsidies, where necessary, might be given.

(iv) that steps should be taken by Provinces and States to prohibit the indiscriminate rearing of goats by persons who have no facilities for the purpose and to issue licences for the rearing of goats, in order to ensure that young plants and trees required for manuring and fuel purposes are not destroyed by these animals.

IV. Seed Multiplication and Distribution.

The Board might reiterate its previous recommendation.

(i) that in view of the fact that the multiplication and distribution of pure seeds of improved varieties of crops is one of the means of increasing food production, the Provincial and State Governments should have a target of seed production to cover ultimately with improved varities of seeds atleast 25 per cent. of the area under each food grain annually.

(ii) that it is essential to have an official organisation for the distribution of improved varieties of seeds so that these may be easily available in time to the cultivators.

(iii) that financial assistance from the centre should be given for the multiplication on scientific lines of seeds and food grains and for its distribution for a period of atleast five years after the expiry of the period already sanctioned.

The Board might also recommend :

(i) The establishment of District nucleussed farms under the direct supervision of Crop Specialists in order to supply larger quantities of improved seeds to registered growers.

(ii) Adequate premium should be given to the registered seed growers for the extra care, trouble, and expenditure involved in producing pure seeds.

In this connection the committee wishes to emphasise that the crops raised from improved seeds usually draw more plant nutrients from the soil and hence require larger supplies of manures and fertilisers in order to keep up the higher yields and that adequate measures should be simultaneously taken to manure properly the lands under improved crops if the extra yield is to be maintained.

V. Vegetable and fruit production :—

In order to increase quickly the supply of nutritive food, the Board might recommend that the cultivation of vegetables and fruits should be actively encouraged for this purpose.

(i) the supply of seeds of suitable vegetable and fruit crops should be made available at nominal cost,

(ii) the cultivation of vegetables, and quick growing fruits like papayas should be encouraged for demonstration purposes in school gardens.

(iii) the improvement of transport facilities and the methods of marketing should be effected.

(iv) greater attention should be paid to raising more food from a unit of land by growing root crops such as potatoes, sweet potatoes, tapioca and quick growing fruits like bananas, pineapples, papayas etc.

VI.—Agricultural Implements.

The Board might recommend strongly that active steps should be taken (1) to make available supplies of iron and steel to cultivators in adequate quantities at cheap rates as it is extremely difficult to procure these commodities for the normal requirements of cultivation and (2) to devise and manufacture improved implements and farm equipment at a cost within the reach of average cultivators and for this purpose the Dominion Government should call for a conference of Agricultural Engineers of the Provinces and States.

VII.—Protection.

(i) It is better to save food crops that have already been grown to food crops in India, the Board might commend the following views of the Food and Agricultural Organization of the United Nations :—

(i) It is better to have food crops that have already been grown at great expense of labour and material than to develop large additional acreage to off-set the wastage caused by pest infestation.

(ii) it is not so much new scientific knowledge that is needed as the more drastic application of what is already known.

(iii) Plant protection constitutes the single most important factor in immediate stepping up of food production.

The Board might therefore recommend :—

(i) that intensive campaign should be carried out in all parts of India against the more serious pests and diseases for which it is essential that the Centre and every province should maintain adequate Plant Protection Organisations for watch and ward purpose.

(ii) that it is essential that there should be close integration of plant protection programmes of various provinces since a number of pests and diseases are seed or air-borne or of a migratory nature.

(iii) that to ensure concerted measures for carrying out the control measures, legislation should be resorted to.

(iv) that the Dominion Government should provide besides other assistance under the Grow More Food Campaign adequate quantities of spraying and dusting machinery without which large scale control measures cannot be carried out properly and in time.

(v) that arrangements should be made for the manufacture of necessary machinery and chemicals in India as soon as possible.

(vi) that the paucity of trained personnel being another bottle-neck in the intensification of plant protection work, the Dominion Government should organise plant protection courses at the centre and in different regions of the country.

VIII.—Publicity and Propaganda.

The Board might reiterate its previous recommendations :—

(i) that immediate attention should be given to the importance of effective publicity.

(ii) that Provincial and State Governments should take action ;

(a) to enlist fuller co-operation of cultivators through organised bodies like co-operative activities, Agricultural Association, etc.

(b) to train the staff of the Agricultural Department in the methods of publicity.

(c) to make available in local languages all useful literature bearing on agriculture.

(d) to publish in popular language the results achieved in the experimental stations.

(e) to make the fullest use of mobile cinemas in rural publicity.

The Board might also recommend that :—

(i) Agricultural training on the general principles of agriculture should be introduced in secondary and training schools, as far as possible.

(ii) that technical men who are now being used by the Department of Agriculture for their State Trading Schemes under the Five Year Plans of food production should be relieved of such non-technical work so that they can devote proper attention to propaganda and demonstration work.

(iii) that the Provincial Governments should arrange to have model agricultural villages one in each sub-division in places where fairs, festivals and weekly markets are usually held for the purpose of demonstrating in a compact area the advantages of adopting the recommendations of the Agricultural Department.

(iv) that in order to encourage the adoption of improved methods of cultivation, an annual prize might be awarded in each village to a cultivator who produces the best results.

IX.—Crop Planning and production targets.

The Committee considered that the question of Crop Planning and fixation of targets of production for the different units of administration required detailed and careful examination in the light of the existing dietary habits of the people in the different regions and the available scope for improvement and that in the absence of relevant particulars from most of the Provinces and States no useful purpose would be served by making any recommendation at this stage. The Committee therefore suggests that the necessary data should be got from the Provinces and States so that the matter could be pursued.

M. S. SIVARAMAN,
Chairman.

SUBJECT No. 6.

To review the measures adopted to increase the fodder production by :—

(a) selection and propagation of perennial cultivated grasses,

(b) improvements in rotational grazing, and

(c) exploration of new fodder crops in addition to improving the existing ones.

Mr. T. J. Hurley presided on 7-4-48, till the arrival of Dr. Parija.

The following were present.

1. Dr. P. Parija—*Chairman.*
2. Sri G. R. Viswanathan.
3. Mr. E. A. Lasarado.
4. Mr. N. C. Dass Gupta.
5. Dr. E.S. Narayanan.
6. Mr. K. Cheriyan Jacob.
7. Mr. H. K. Lal.
8. Dr. L. C. Sikka.
9. Mr. T. J. Hurley.
10. Sri P. D. Nair.
11. Dr. T. J. Mirchandani—*Secretary.*

2. There was general discussion on the subject. It was felt that the fodder production has been given a secondary place in the Agricultural Development plans. But the Committee felt that the production of fodder should get higher priority with a view to ensuring the health of the work cattle and increasing the production of milk which is one of the best protective food. The mainstay of the agriculturists is the cattle and without healthy cattle, there will be a set-back to the food production. In view of this the Committee felt that all avenues to increase the fodder supply should be explored.

3. The Committee reviewed the work so far done on the selection and propagation of perennial cultivated grasses. It was noted that while some work has been done in the past in some Provinces, it has not been sufficiently intensive. Recently systematic work has begun at the Indian Agricultural Research Institute. Work has not progressed far enough for any definite conclusions or recommendations to be made. The reason for this appears to be that the Agricultural Department| Animal Husbandry Department did not have a separate staff for this purpose. Even where the Departments of Agriculture and Animal Husbandry have been able to recommend suitable grasses, the cultivator has not taken them up because it means diverting a part of his land from food and cash crops and also because he does not appreciate the indirect benefit he receives from the increased fodder production.

4. The Committee therefore recommends :—

A. (1) That in each Province and State, there should be an Agrostological Section to Study the fodder problem in all its aspects which will include (a) collection of grasses (both indigenous and exotic), (b) their trial under local conditions, and (c) their cultural, manurial and hygienic requirements. The Central Government should help the Provinces and States by collecting suitable fodder and forage plants and supplying them for trial.

2. That the Departments of Agriculture, and|or Animal Husbandry should undertake immediate experiments under Comparable conditions to work out comparative data regarding economic and nutritive returns from the perennial grasses at present known and the alternative cultivated fodder.

3. That the Departments of Agriculture, and|or Animal Husbandry in the Provinces and States should recommend to the cultivators suitable grasses and legumes for growing as fodder, encourage them by means of concessions in the form of subsidised sales of seeds, bounties in cash concession in water-rates, and|or abatement of assessment for fodder cultivation.

4. That the possibility of utilising waste lands in the villages, field bunds and tank banks should be explored for growing suitable perennial and other fodder and forage plants. The attention of Irrigation Departments should be invited to the possibility of growing perennial grasses along irrigation channels.

B. (1). rotational grazing has recently been tried with success in some parts of India. The Committee strongly recommends that this system should be extended to suitable forest and waste lands in the Provinces and States, and that the carrying capacity of such lands should be studied simultaneously. In this connection, the Committee is of opinion that the Land Utilisation Board contemplated in Resolution No. I on Subject No. II of the 6th meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry should be entrusted with the planning of fodder production in waste lands.

(2) That in order to improve rotational grazing (a) steps should be taken to provide watering facilities for cattle, (b) useless scrub jungles should be removed and (c) moisture should be conserved in those areas where the land is sloping.

(C) (1) The Committee is aware that work is being done in the Provinces and States for the improvement of existing fodder crops ; but there is much scope for more intensive work in this direction. The Committee recommends that the new Agrostological Sections suggested in Resolution A(1) be entrusted with this work.

(2) As there is great scope for exploration of new fodder crops, attempts should be made to utilise plants which have not so far been used as fodder crops and also new plants including perennial legumes (both indigenous and exotic) should be collected, to be tried as fodder. In judging the suitability of fodder crops, its nutritive value and its toxicity to animals should be investigated before it is recommended.

(3) Arrangements should be made for supplying to the cultivator seeds of recommended fodder crops, particularly Berseem, the seeds of which are not easily available. The possibility of utilising bees for securing better setting of seeds in crops like *Berseem* should be explored.

(D) That the Committee feels the necessity for an illustrated handbook on Indian Fodder and Forage Plants and suggests that the Indian Council of Agricultural Research may undertake its compilation.

P. PARIJA,

Chairman—8-4-48.

SUBJECT NO. 7

The Rotation of Crops which will give the Best Results in an Irrigated Intensity from 35 to 70 acres out of 100 acres.

The following were present.

1. Rai Bahadur Venkata Acharya—*Chairman.*
2. Mr. C. Vijayaraghavan.
3. Mr. M. N. Lakshmana Rao.
4. Mr. T. S. Venkatarama Iyer.
5. S. Shamsher Singh.
6. Mr. S. Sen.
7. Dr. J. K. Basu.
8. Dr. P. C. Raheja.
9. Mr. Subbiah Mudaliar.
10. Mr. R. N. K. Sundram.
11. Mr. M. Abdul Majid.
12. Mr. S. S. Selot.

ITEM I—AGENDA

The Sub Committee observes that the agenda as presented to them contains only one subject whereas this section of the Board of agriculture has been handling other subjects—vide items I (a) to (c) on irrigated farming—Agenda for the meeting of December, 1945. The Sub Committee suggests that a continuing agenda may be framed for this section of the Sub Committee and the subjects so far *accepted be listed out and continued on the agenda from year to year* and the progress recorded. The Sub Committee suggested that the following may be included in the agenda in regard to work so far considered and discussed in the Board.

Subject—Item I.—Irrigated farming.

(a) Water requirements of irrigated crops with special reference to the optimum use of limited water supplies.

(b) The effect of the depth and the incidence of irrigation on crop yields.

(c) The measures to be adopted to prevent accumulation of harmful salts in irrigated soils and to reclaim the soils so impregnated.

(d) Rotation of crops which will give the best results in an irrigation intensity of 35 to 70 acres in 100 acres.

Item I (D) of the Suggested Agenda.

The Sub Committee feels that the term 'Irrigation intensity' must be defined so that the members may clearly understand the scope of the work listed under this head The following draft resolution was therefore suggested.

Draft Resolution

The Sub Committee resolves that the following definition be adopted for the term 'irrigation intensity'. The term 'irrigation intensity' is applied to the percentage of culturable irrigable area irrigated during a year or season. Taken over a whole year the term use is annual intensity and this is the sum of percentages of culturable and irrigable areas irrigated in each of the two seasons in a year. For the purpose of reckoning intensity the percentage of a duffasil crop like sugarcane or plantains standing on the ground for more than one season should be doubled.

Item I (d) of the Agenda.

The Sub Committee considers that the scope of the subject included in the agenda should be enlarged to include irrigation intensities greater than 35 to 70 per cent., which is only applicable to some areas in Northern India. There is quite useful field for experiments in rotation of crops in some provinces where irrigation intensities are less than 35 per cent. or in many States where they are much greater than 70 per cent. For instance, in Bombay, Madras, and Mysore irrigation intensity is never less than 100 per cent. and the subject as on the agenda should normally include experiments on rotation of crops on such areas. The enlargement of the scope is therefore desirable and necessary. The following draft resolution is therefore suggested:

Draft Resolution

The Sub Committee suggests that the subject included in the agenda may be enlarged in scope to include irrigation intensities greater that 70 acres per 100 acres and may therefore be worded as follows :—

"*Item I (d).* The rotation of crops which will give the best results in

(i) irrigation intensity of 25 to 70 acres in 100 acres.

(ii) irrigation intensity greater than 70 acres in 100 acres.

The Sub Committee discussed the subject 7-1 (d) under the following heads :

(a) Definition of intensity of irrigation.

(b) Factors affecting determination of intensity of irrigation and rotation of crops in relation to

(i) Soil conditions

(ii) Climatic conditions.

(iii) Irrigation supplies available.

(iv) Water table.

(c) Observation so far made and summary of results

(d) Suggestions for future work

(i) Organisation

(ii) Scheme of experiments.

(iii) Collection of data.

(e) Any other subject.

A draft resolution under (d) has been framed and is put up before the Board.

(b) & (d) Notes of discussion are recorded and the Sub Committee has no resolutions to propose.

(c) Notes of discussions are recorded and Sub ·Committee proposes the following draft resolutions.

c (i) Organisation

Draft Resolution.—The Sub Committee recommends that the existing Research organisations in the various provinces and states should be enlarged and expanded to the extent necessary and new organisations set up where none are available to study and carry out experiments on a co-ordinated basis on rotation of crops both on experimental stations and on cultivator's fields.

c (ii) Scheme of experiments

Draft Resolution.—In regard to methods and scheme of experiments, the Sub Committee recommends that work may be done on the following lines :—

(i) a soil survey of the tract should be undertaken and the soils classified according to the genetic system. Experiments on special soils such as saline, alkaline, and water logged sails should be carried out separately from general experiments on other soils.

(ii) The seasonal and climatic conditions.

(iii) (a) The irrigation supplies available in regard to the total volume and its seasonal and daily distribution.

(b) Economical use of water and sale by volume.

(iv) The conditions of water tables and its relation to season and rainfall and irrigation sources,

(v) Scheme of rotation of crops to take note of items (i) to (iv) and ryots' needs and economics of cultivation by way of (a) food, fodder, green manure, cash commercial and Leguminous crops and (b) availability of manure and its relation to the allied problem of use of animal dung as fuel. Selection of crops will be left to the provinces and States.

(vi) Suitable safeguards in the scheme of experiments should be provided to allow for border effects and different crops in adjacent areas and reproduction in research stations of conditions of practical value applicable to ryots' fields.

(vii) In case of field experiments under ryot's conditions, the scheme of crop rotation should vary in relation to the soil zones and other factors such as village sites, malaria incidence etc,

(viii) Where sowing and planting of a crop extends over a period. e.g. 45 days, in transplantation of rice crop, effects of variations in the actual dates and periods of sowing and planting within the total period of 45 days should be studied.

(ix) With a view to study long term effects of crops in soils, experiments should cover at least 3 rotational cycles, with all the crops of the rotational appearing in each year.

(x) There should be full co-ordination between Irrigation and Agricultural Departments in these experiments. The notes of discussion contain tentative suggestions for cropping schemes under differing conditions of intensity and workers may be invited to study these notes and the work done in

(a) Lyallpur farm in the Punjab.

(b) Sugarcane Research Station, Shahjahanpur.

(c) Sugarcane Central Research Station, Pusa, Bihar.

(d) Sugarcane Station, Padageon, Bombay.

(e) Agricultural Research Station, Siruguppa, Bellary District, Madras.

c (iii) Collection of data.

In regard to collection of data, the Sub-Committee recommends that the data collected should include the following :—

(a) Genetic Soil types.

(b) Daily rainfall and temperature, humidity and other meteorological factors.

(c) Irrigation water supplies, quality of water.

(d) Rise and fall of water table, and quantity of ground water.

(e) Crops yields and economics of cultivation expenses and not return to the cultivator.

(f) Incidence of weeds, insect pests and diseases.

SUBJECT No. 7.

Items I (a) to (c) on the agenda.

The Sub Committee records the note on the progress made under the above items of the agenda. Only two provincial Governments and two states have replied. The replies from other Governments may be called for and the matter discussed at the next meeting. The Chairman mentioned that the matter was discussed at a recent meeting of the Irrigation Development Board, Madras and the views of the Board would be reported to the Indian Council of agricultural Research in due course. A scheme of experiments in regard to rice crop ,with a view to determine the requirements of water for the maximum yield of crop per acre, irrespective of quantities used the maximum yield per Cft. of water irrespective of area irrigated, is under consideration.

APPENDICES I—VII

APPENDIX I

SUBJECT No. 1(a).

The need for breeding crop varieties adopted to varying levels of Soil Fertility and for special condition of soil and climate.

BY

DR. R. V. TAMHANE,

Indian Agricultural Research Institute, New Delhi.

For a successful growth of plant in crops production, knowledge of the requirement of the plant and the knowledge of the capabilities of the soil is very essential. Soil is very much like a living thing born of parent rock and slowly developing under the influence of climate, vegetation and relief. Although climate is largely responsible for different type of vegetation yet there is a close relationship between soil and climate, partly directly but more largely indirectly through the vegetation. Climate and vegetation as they impinge upon the parent rock may be regarded as the active force in soil formation yet cognisan of topography is also taken in the formation of local soils.

2. Productiveness depends upon maintaining the correct balance of mineral elements and humus content in the soil. The fertility of virgin soil is associated with continuous supply of organic matter they receive from natural vegetation. The mere act of cultivation tends to reduce this supply in many soils. Vegetation introduces the biological factor into soil formation. The organic matter which ultimately returns to the soil becomes the food of a varied and multitudious population of insects and micro-organism. But the chief climatic factors-rainfall, temperature and humidity influence the amount of various chemical elements and compounds in the soil In humid regions where there is a large excess of rainfall over evaporation, leaching of more soluble substance takes place and many a time they are lost from the soil. Through the washing, the soils in humid region have lost much of their lime, potassium and some other elements too. While on the other hand the influence of the vegetation on the soil type becomes less and less as the climate gets drier. In dry regions the soils have kept much of the calcium, potassium and sodium. To a far greater extent, however, the plant genera and determined by the chemical and physical properties of the soil and particularly of its salt content, which assumes a predominant importance in the soil and alkaline soils of very arid regions Broad plant communities will be found to coincide with soil association. Various plant communities indicate saline or alkaline patches, free or impeded drainage or drought condition. Thus soil. climate and vegetation might be regarded as a complex of which development of each is dependent on the other.

3. However, in time the soil approaches an equilibrium in which the forces of depletion—leaching, erosion and removal of material by plants and animals balance the forces of removal. If any factor of environment e.g., the vegetation, climate, and slope varies the soil will take on a different character and will tend towards a new point of equilibrium. But such changes occur in nature usually very slowly. Climate may also change gradually, but when man removes the native vegetation and replaces it

with plants of his own choosing an enormous change is sometime made. This change may improve the soil and make it more productive for the future or it may reduce its productivity, depending upon the crops grown, the management practices and the soil condition.

4. With all the limitations mentioned above it is still possible to make some progress in having suitable varieties of crops for different tract in the Dominion. In India on a very broad basis there are nearly 21 major soil groups and 10 major climatic belts. Even within these major groups there are many types which are not yet identified and studied. Yet taking on a broader group viz., Black soils, these soils vary in depth from as shallow as 1 to 2 feet deep to as deep as 20 feet. Different varieties of crops like cotton, wheat, jowar, Bajra are associated with this type. So widely has cotton become adapted to different climate and soil condition that short staple but strong cotton variety is grown in some parts of Bombay Province, while a better quality is taken in parts of Central India, Central Provinces and Berar and also in some parts of Gujarat (Bombay). Similarly in soils of high salinity growing particular variety of crops which will deplete the soil of its high salt content becomes a necessity. Some salt resistant varieties of rice and some legumes are many a time taken to reclaim such soils. The varieties of sugarcane and its growing has been developed in India on its adaptation to particular soil and climatic condition. There are many different kinds of sugarcane known in India. Northern India for example has thin variety which has very well adapted to the region while in Southern part of Vindyas a thick variety of cane is found more suitable. Thus the situation of sugarcane growing has been completely changed within the past few year and a number of variety of canes have been put forth that are far better producers than those used in the past. Growing of legume to improve the fertility has been established. Berseem appears to be one of the legumes that can be grown under Northern India condition where low temperature and water facilities exist. Even in the same variety different species response differently e.g. Lupins (a legume) differ in this adaptation to soil of different fertility levels. Yellow lupins do well on moderately acid, light sandy soil of low fertility. Blue lupins require neutral or slightly acid soil of moderate fertility, while white lupins need fertile, neutral soil for satisfactory growth.

Thus there arises a need to have different varieties of crops for different levels of soil fertility. The climate of a given region is seldom entirely favourable to all the crops we may need. High temperatures may interfere with satisfactory crop production and a low temperature, may reduce yields or quality. Similarly the moisture variations may be beyond the adjustment limits of the crops, the common experience being a short crop because of draught.

Futher the climatic conditions very decidedly affect the severity of plant diseases and if these are favoured, they may be limiting factors in production. The fertility of our soils is constantly being reduced by the erosion menace. Vast areas have been ruined by erosion and to restore these areas and to control further the ingress of erosion we have to develop cripping system which should include the soil binding varieties of grasses and fertility building varieties or legumes to develop the affected areas.

Climate cannot be changed to suit the crops nor the soil be changed so easily. Nature imposes here a limit and to adopt a plant to a drastically changed environment requires that some distant cousin (a plant genus) which can thrive under such conditions be available for plant breeder to use in hydridization. So the best way to derive full benefit of the Existing condition of soil and climate in India is to develop suitable varieties of crops to suit the different tracts of India. For such investigation we need to know our soils correctly and then such a programme will be feasible. In U.S.A. investigation on hybrid-corn has yielded much profit to the nation as well as to the cultivator. Similarly research on cotton has developed one variety community programme to produce uniform lots of high quality cotton. Without improved varieties there would be no incentive for the farmer.

SUBJCT No. 1(a).

" The need for breeding crop varieties adapted to varying levels of soil fertility and for special conditions of soil and climate ".

B., P. PAL AND N. PARTHASARATHY,

Division of Botany, Indian Agricultural Research Institute, New Delhi

Crop yield is the measure of the response of the crop to the interaction of environmental factors on its genetic make-up. The wide variation in the yield of any particular crop (e.g. wheat, rice sugarcane, etc.) recorded in the different regions of India is therefore a measure of the economic suitability of the crop for those regions. The Plant Breeder's function has been to evolve types with different genetic constitutions to fit in as best they may in the respective regions for which the improvement in yield was required. Successful results have been achieved to a great extent in sugarcane and to some extent in other crops like wheat and rice. Such success depended on the nature of the crop and the availability of suitable plant collections for use in breeding.

Considering the wide ranges of climatic and numerous soil types and the different agricultural practices obtaining in India the problem of crop improvement through breeding cannot be a simple one, as it must involve the study and estimation of responses to the clearly analysable environmental factors which affect plant growth. Some of these factors, e.g. agricultural practices like sowing, spacing and manuring, can be altered at will, but other important factors such as the season (which is always subject to changes) and the soil with gradations in its nature and fertility, are difficult if not impossible to control.

The cultivable tracts in India fall into at least ten major climatic belts and most of the crops are found distributed in more than one of these belts. The yield figures are therefore not uniform and vary considerably showing the broad effects of climate on crop growth. Experience has led to the choice of suitable varieties or species in the different climatic regions and this has to a great extent off set the limitations due to clima

Although climate representing mean annual rainfall, mean temperature and hours of sunshine is an important factor for plant growth and limits the adaptability of crop species and varieties, it is recognised that the foundations of crop culture is the soil and crop growth is the resultant of a single biological system involving the nature of the plant, the soil and the enveloping atmosphere. The crop is therefore at its best when it is in harmony with its growth environment.

The question arises as to how far the present methods of breeding crop varieties are satisfactory and on what lines modifications need to be made to fit in the most efficient strains or varieties in relation to the growth environment.

Breeders have no doubt recognised the limitations of climate and the picking out or selection of plants is therefore carried out in local varieties or in hybrid populations, in the respective representative climatic tracts. However, such selection and tests for yield have been and still are being carried out at a single level of soil fertility which is believed to be obtaining in the locality or region concerned. From the report of the All India Soil Survey Scheme (Roy Chowdhri 1946) it may be seen that the extent of soil diversity obtaining in the provinces and States of India is so wide that at least 21 major soil types can be identified and so any marked differences in the responses of varieties to different levels of soil fertility and soil types would naturally modify the performance of the strains envolved at one level of soil fertility. It is only if such differences are non-existent or quite unimportant that the relative value of diferent varieties as shown by trials under a single test of soil conditions can be regarded as reliable and conclusive. Actually, recent experiments have shown that this is not the case and varieties respond differently to soil type and manuring.

Experiments conducted on cotton varieties (Growther 1938) in Egypt under different levels of nitrogenous manuring have established the differential responses of the varieties to manuring. In Pusa, one of the newly evolved wheat strains under trial proved to be superior to N.P. 52 under manured conditions while under no manure the latter type was the best (Report of Imperial Economic Botanist, 1933-34, Indian Agricultural Research Institute).

That varieties respond differentially to different fertility levels of soil is also amply illustrated by the experiments on wheat (Lamb et al 1936) and maize (Moers 1933). The responses were so very distinct that in some cases there was a reversal of the order of performance under different fertility levels. (Worzella 1943) studied the grain yield and total weight straw and grain) data for five varieties of wheat grown on three levels or soil fertility on each of three soil types during the five year period of 1936-41. Some varieties yielded relatively highly on the well fertilised plots while others were more efficient on the low fertility plots. Similarly, Jenkins et al (1934) have indicated the possibility of developing strains especially adapted to soils of high or low fertility. The selection of a variety therefore depends upon its efficiency for maximum production under a particular level of fertility.

Investigations on the behaviour of varieties regarding their responses to important manurial ingredients, such as phosphate and potash, have also brought out the fact that varieties can be bred for growing in soil types known to be deficient in some essential constituent for other (Gregory and Crowther 1931, Lyness 1936).

Investigations on the responses of wheat varieties to different levels of fertility are now in progress at the Indian Agricultural Research Institute.

The varietal preferences are so very subtle that even alterations in cultural practices may have a distinct effect in their responses. Sukatschew 1928 has shown that altering density of the total number of plants per plot alters both the survival of seedlings and the fertility of the survivors in *Taraxacum* and a pure line which was inferior under one set of conditions might oust the rest when conditions were changed.

The above results have a direct and important bearing on plant-breeding and variety testing programmes. Growther (1938) has rightly remarked that " the existence of interactions between variety and manuring, both nitrogenous and phosphatic, suggests that similar varietal differences will arise on soils which differ naturally in supplies of soluble nutrients. Thus, in experiments laid down for the purpose of variety selection it may well happen that the varieties will emerge in one order of yield on land of high fertility, in a different order on land deficient in available nitrogen and in a third order on land deficient in phosphate. A plea is therefore addressed to plant breeders that they not only lay down their variety trials on sites representative of the different soil types, but also adopt generally the practice of including manurial factors, not merely in the final commercial tests but even in the early stages of selection. A combined factor experiment need not involve a great increase in the number of plots, for the usual number of repetitions of each variety can be distributed over the manurial comparisons, providing both a straight comparison of the behaviour of the individual varieties with different types or rates of manuring".

The reorientation of the breeding programme as outlined above is particularly important in industrial crops like sugarcane, cotton, etc., where ample facilities for a high level of cultivation in the shape of manure, irrigation, etc., are not lacking. It is the task of the breeder, therefore, to select the right type of variety which will yield best under optimum conditions of manuring in relation to the different soil types. In the case of food crops also, in which there is a growing deficit of production in the country, it will be necessary to change the method of breeding and cultivation. If more food grains are to be produced it can be done only by increasing acre yields as not much new land is available for cultivation. Acre yields, however, can be increased only by improving the soil productivity by proper manuring and irrigation and growing suitable varieties that will respond to high level farming. Varieties will thus have to be selected and tested under different levels of manuring related to the various soil types and only those which will give maximum yields under optimum conditions released for distribution to farmers.

It is consequently important to consider the requirements of the cropping system as a whole and to maximize production. There is need for research for obtaining a favourable balance of the important mineral nutrients, organic matter, microflova and suitable physical conditions of the soil. The plant breeder has therefore to produce types under an environment geared to a high level of fertility, commensurate with economic returns. He has to lay down his trials for selecting of varieties under conditions of sound farming practices determined by coordinated experiments conducted by the Agronomist, Chemist, and Soil Physicist working together, in typical localities representing the different climatic and soil belts.

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SUBJECT No. 1(a).

Note by Dr. R. D. Asana, Division of Botany, I.A.R.I. on subject No. 1.

The importance of estimating the effect of environment is almost patent in the case of a breeding programme aiming at producing varieties of crops suited to special requirements of particular areas. The simplest way of estimating this effect obviously is to try out in different environments varieties produced in one locality. This method is evidently labourious and time consuming. Could it be short-circuited by any means ? In other words, could the performance or suitability of varieties under different environments be predicted with a reasonable degree of accuracy without resort to the extensive and laborious trials referred to above ? Unfortunately it is not possible to answer this question unequivocally in the affirmative. For achieving this objective it would seem necessary, in the first instance, to have information on certain broad correlations between growth and yield and environmental factors of major importance. It is intended briefly to discuss the lines in which information in this connection could profitably be sought. A specific case, viz., wheat breeding in India may be considered.

Temperature, as Howard (1924) pointed out, is an important environmental factor in wheat production in India. "After the monsoon, the sowing of wheat is regulated by the point reached in the gradual cooling of the seed bed. Towards harvest the crop has to ripen under a rapidly ascending temperature when hot dry winds are frequent. To some extent therefore, wheat growing in India is a gamble in temperature". Chinoy (1947) has also obtained quantitative data confirming Howard's generalization.

There is also to be seen within the country a gradual decrease in the length of the growing period with decrease in altitude, due no doubt to its inverse relation with temperature.

Day length is also important factor influencing growth and development of the wheat plant but within the country it does not seem to be (at least in the main wheat growing tracts) as important a factor as temperature as indicated by the data in table below :

Mean Day length (from sunrise to sunset) in hours and minutes per day.

Tract ..	Latitude	November	December	January	February	March
Delhi ..	30°N	10, 42	10, 16	10, 24	11, 13	11, 54
U. P. ..	32°-24°N	10, 23-10, 58	9, 51-10, 37	10, 2-10, 44	11, 7-11	17, 11, 51 11, 59
Bihar ..	28°-22°N	10, 42-11, 13	10, 16-10, 57	10, 24-11, 2	11, 13-11, 28	11, 54, 11, 58
Rajputana and C. India.	30-22°N	10, 42-11, 13	"	"	"	"
C. P. ..	24-20°N	10, 58-11, 13	10, 37-10, 59	10, 44-11,2	11, 17-11, 25	11, 59, 11, 58
Gujrat, Kathiawar, Khandesh.	23-20°N	"	"	"	"	"
Hyderabad (Deccan)	20-10°N	11, 13—11 27	10, 57-11, 15	11, 2-11, 19	11, 28-11, 38	11, 58, 12,0

The adverse effect of atmospheric drought (rapidly ascending temperature and hot dry winds) at the time of the ripening of the grain can, however, be countered by growing early maturing types. Unfortunately, the early maturing types posses, generally speaking, low tillering power as compared to late types. It would seem, therefore, worth exploring the range of variability as regards tillering in the early types and also examining how it is influenced by temperature. It is felt that this information would be of considerable help in assessing the adoptability of a variety, bred for instance in Northern India, to central and peninsular Indian conditions.

Another important factor influencing wheat production in India appears to be soil moisture. The average yield under irrigation is, on the whole higher, the difference being accentuated in seasons of deficient rainfall. The area of non-irrigated wheat tracts is, however, by far the greater. It would seem useful to investigate whether growth and yield of wheat suffer at the oil moisture level between wilting coefficient and field capacity. Opinion is divided regarding the effect on growth of soil moisture between these two limits. According to Veihmeyar and Hendrickson (quoted by Kramer—(144)—) the growth and quality of apples, near, grapes, peaches, prunes, walnut and cotton were not affected by the moisture content of the soil unless it fell to wilting percentage and remained there for some days. These plants did no better on frequently irrigated plots than on plots where the soil moisture was allowed to fall to the permanent wilting percentage before Water was applied. As opposed to this view Kramer cites considerable evidence to indicate that water is not equally available to plants over the entire range from field capacity down to permanent wilting. Preliminary experiments at the Indian Agricultural Research Institute also indicate that growth of wheat does suffer between these limits of soil moisture. It would seem useful to investigate whether there is any difference between varieties in regard to tillering and growth between these limits of soil mojsture. If varietal differences in respect of this are found to exist the stage would be set for the other more arduous investigated of correlating these difference with morphological and physiological characters and their mode of inheritance.

Yield is related to ear size, fertility of spikelets, grain weight etc., besides tillering. The recent observations of Singh and Alam (1944) Lyallpur indicate that spacing as well as sowing date have considerable effect on the number as well as fertility of spikelets. It would seem, therefore, useful to determine how far these characters of different varieties are modified by environment.

In regard to the problem of breeding varieties to suit different nutrition levels of the soil it may be suggested that the differential response, if any, is likely to be modified by the length of the growing period as influenced by environmental factors, particularly temperature. For instance, a variety bred at Delhi might show differential response to nutrition levels under Delhi conditions but may not necessarily do so in another environment where the growth period is shorter.

How far do physical properties of the soil influence growth of wheat is worth considering in relation to the distribution of varieties in India. In the non-irrigated areas of central and peninsular India durum wheats predominate whereas the 'vulgare' wheat appear to be typical of the alluvial soils of the plains.

Since about 30 per cent. of the total dry matter of the plant is assimilated after ear emergence the effect of environment during the post-emergence period on different varieties requires also to be investigated.

To sum up, the following lines of study are suggested as preliminary steps in a breeding programme aiming at producing varieties of wheat suited to different tracts of India :

(a) The range of tillering in varieties, particularly of the early and medium types ;

(b) Influence of temperature and soil moisture on tillering;

(c) Influence of temperature and soil moisture on growth after ear emergence and on ear characters-:

(d) Interaction of nutrition levels with length of wrowth period.

Not much difficulty should be experienced in effecting control of temperature in these conditions, especially at Delhi, since the temperature, requiring to be studied would be higher than prevailing ones and this could be more easily manipulated by means of electric heaters than if it were a case of maintaining lower temperatures.

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A note on the need for breeding crop varieties suitable for different soil and climatic conditions, with especial reference to sugarcane in the United Provinces (Item I of Agenda)

BY

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Each individual crop variety or a species is the resultant of the interactions between the innate equipment or heritage and the environment. Innate equipment is the most important factor in determining the type of the individual variety, since it is with this that the individual starts its developmental life. Evironment too is no less important, for due to the lack of a suitable environment a good heritage may come to naught like a good seed sown on stony soil. Nevertheless, it is true that even the most optimum environmental condition cannot make up for defective heritage. Any breeding programme for the future should, therefore, take both of these factors into consideration, since one without the other will be inadequate, and will only result in the wastage of efforts of the plant breeder. Sugarcane crop in this country is grown under very diverse soil and climatic conditions, which have resulted in special local adaptations of varieties. If any further success is to be desired in increasing yields per acre, the attention of the cane breeder must be directed to evolving new varieties which could adapt themselves better to the local conditions of soil and climate.

Soil and climatic factors determine principally the success or failure of a variety in a particular locality. A variety suitable in Peninsular India, Bengal or Assam may not be suitable for the plains of the United Provinces. Even within a Province the suitability of varieties may vary from place to place. Co. 395, Co. 393, Co. 370 and Co. S. 109 are all suitable for the Eastern districts of the United Provinces, but are a failure in the Central and Western districts. Although the genetic make up of a variety remains the same at all places, yet it responds differently to varying soil and climatic conditions. At a place where the interaction between the genetic make up and the environment complex is favourable, the yields are high ; while at places where the interaction between the genetic make up and the environment is unfavourable the yields are low. The breeder cannot, therefore, supply a ready-made pattern for every locality by just confining himself to one locality. If he does it, he is leaving too much to chance in the earlier stages of selection, and is thus likely to lose a considerable amount of promising breeding material which have been good elsewhere. An instance may be cited. Some seedlings were raised at Shahjahanpur from fluff collected locally. All these seedlings presented a poor performance at Shahjahanpur and were rejected for further inclusion in trials at the station. Thinking that they might fare better at Gorakhpur, they were sent there and showed good results What was a ' rejection ' at Shahjahanpur was a ' selection ' for Gorakh What was a 'rejection' at Shahjahanpur was a 'selection' for Gorakh-pur. This shown how important is the problem of primary selection in

The present method of evolving sugarcane varieties, besides introductions from abroad, is based on bringing together of parents which are calculated to impart to their progenies the characteristics desired for a particular environment and then to make selections year after year out of the innumerable forms thus obtained. But this is hardly enough. The cane breeder has no proper criterion for selecting his seedlings excepting visual observations which are often quite deceptive. As the sugarcane is a heterozygous polyploid, and when propagated through seed throws out innumerable diverse forms, grading from wild *Saccharum* types to good thick noble types, the problem is further complicated.

Varietal differences are subordinate to soil, climatic manurial, irrigational and other cultural treatments. It has been found out that environments contribute so much to the variability of the breeding material that genetic effects may remain undetected by the usual methods of testing. A variety supposed to be medium or late in ripening may actually ripen earlier or later in a different environment. Co. 453, a medium-ripening cane variety in the Western and Central districts of the United Provinces, become early in the eastern districts and proves even earlier than Co. 343, a standard early variety. When such are the differences caused by soil and climatic conditions on the performance of varieties how can the breeding work be centralised at one place? Should not, therefore, the work of breeding varieties be carried out at various centres distributed all over the country? The fixing of these stations should be based on geographical classification of the country according to soil and climatic peculiarities. This is a pre-requisite to starting off any sound breeding programme, if any advance on right lines is to be desired for securing varieties adaptable to different soil and climatic conditions. Variability of seed material under all climatic conditions no doubt forms a very serious limiting factor to the success of breeding work in sugarcane, but recent physiological researches seem to have paved the way for overcoming this obstacles. Geographical classification of the country according to climatic and soil regions will not only put breeding work on sound lines but will also go along way to helping the agronomist in preparing proper manurial and cultural schedules.

Climatological classification of the United Provinces on the basis of Lang's factor has already been done and is likely to serve a very useful purpose in deciding future lines of work in crop breeding. The province on this basis has been divided into well defined climatic regions. Each of these regions neeeds to be surveyed according to morphological, physical and chemical properties of the soil. This is a huge task and must be finished as early as possible. The usefulness of this work is very well established and was realised by this Board long ago. Soil survey which was taken on the Agricultural Chemistry Section of the United Provinces is still in its infancy but whatever has been done in the few districts has already attracted the attention of the cultivators as well as the owners of large farms, and the results emerging from the survey are being widely utilised. This survey has also helped us in locating places for our zonel trial work which has been mainly started in this province for selecting varieties and formulating manurial schedules for different localities, differing among themselves in climate and soil types.

Each soil tract within a particular climatic belt should form the unit for work on breeding and selection. Plants in a particular soil tract have been growing there for generations and have adapted themselves to the local agricultural and climatic conditions, and now they exist in a static equilibrium with the environment. These plants, both wild and cultivated, should form the breeding material for future evolution of crop varieties. This material will provide, like a stock to the scion in garden plants, a well adapted root system and physiological make up, resistant to the fluctuations of the local factors-indispensable for the success of a new variety in a particular tract.

Root system is an important part of the plant. The adaptation of a variety mainly rests upon it. Some work on the relationship between the roots and the soil types has been done at Gorakhpur as well as at Shahjahanpur. The results obtained clearly show that there exists an interaction between the type of the root system and the type of the soil. Resistance to drought, water-dogging and abnormal soil formation is mainly correlated with the root system of the varieties. The varieties which are resistant to these factors possess root system which can have their spread and absorption under those peculiar conditions. There are numerous cases where varieties have failed in a particular soil tract not owing to the unsuitability of the climate, but due to some quality of the soil inhibiting root growth. But when factors which retarded the growth of the roots were removed the variety grew very well.

The study of the relationship between the root formation and the soil is still in a preliminary stage in this country. But intensive work on this line will undoubtedly release valuable information on the suitability of the varieties to different soil tracts. This information will also help the breeder in spotting out varieties suitable to different soil tracts even before they are tested in a regular varietal trial.

Varieties respond difficulty to manuring. At Shahjahanpur a significant interaction has been discovered between varieties and level of soil fertility. Medium and late ripening cane varieties, like Co. 421 and Co. 331, generally show a better response to nitrogenous manuring than the early ripening ones. For the same quantity of manuring, an early variety will give a lesser return per lb. of nitrogen applied than the medium and late ripening varieties. It is an important point and has much bearing on securing high yields within economic limits. In breeding varieties for sugarcane, therefore, attention should also be directed to the discovery of varieties which might give better return for every lb. of nitrogen added to the soil.

Our yields are generally lower than what are obtained in the other sugarcane growing countries of the work. Breeders are criticised for this low yield. But perhaps it is not generally realised that there are numerous considerations which have to be kept in mind before such comparisons are made. Our country is in fact a large continent having widely divergent climatic and soil regions. In other sugarcane producing countries, the areas under sugarcane are comparatively more compact, the climate is far less divergent and the growing season far longer than what is obtained in most parts of this country. Plant breeding in

sugarcane has already achieved spectacular success in increasing our yields. But this success can be much more if breeding of varieties be adapted on regional basis, so that varieties suitable for every soil tract and environment could be discovered. By extending breeding work to different regional stations, distributed all over the country according to different soil and climatic regions, it should be possible to evolve and formulate *selection standards* by isolating characters which contribute to yield, and by establishing various morphological, chemical and physiological relationships between the varieties and the environment. This alone can ultimately bring about an effective and rational improvement in our present methods of evolving crop varieties suited to different tracts.

A NOTE ON SUBJECT I(a)

" The need for breeding crop varieties adopted to varying levels of soils fertility and for special conditions of soil and climate "

BY

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The need for evolving crop types suited to different environmental conditions is undoubtedly very great. Crop environment of a given region is the influence of the interaction between the climatic, edaphic and biological factors operating there, and quantitative plant growth depends on a harmonic balance of such factors. A breeder often finds that a particular crop type is not suitable to different soil in a tract. In a region soils may *greatly differ in their fertility. The soils of the hill* ranges differ from those of the plains as well as from those of the vallies below. Taking a concrete case of the Bombay rice tract, we find a definite natural fertility gradient running along thee terraced beds from top to bottom, with a result that the higher poor lands can only support early types of rice, the intermediate zone, the midlate types and the lowest rich beds are suited to the late types, thus the level determines the natural soil fertility. Consequently the breeder has to evolve early, midlate and late types of the same local variety to suit the graded requirements of the region (Salimath and Khadilkar 1935). Such rice types maturing at different times, and thus suited to different fertility levels of the land, have therefore been evolved in Bombay to serve the principal rice tract (Dep. Agri. Bombay Leaflet 1944).

Similarly natural soil fertility greatly differs according to the geological, chemical mechanical and biological properties of the soil. In Bombay there is considerable variation in soil fertility ; the alluvial soils of Gujrath, the trap derived areas of the Deccan and the mixed soils of Konkan and Karnatak, often baffle the breeders who strive to evolve suitable crop types for these varying regions (Sahasrabudhe 1929)

Two competing sister types of Mugad paddy, viz. M-81 and M-249, evolved at the Rice Breeding Station, Mugad (Dharwar), were found to be suitable to two entirely different regions of Karnatak ; M-81 found favour in the Belgaum and Dharwar districts ; while M-249 was found suitable in the Norther Kanara district.

A breeder has to cater for the needs of special soil conditions also. Again taking an example from the rice area, sweet rice lands differ greatly from the contiguous coastal salt-land rice belts. Similarly the sugarcane areas of the Deccan canal regions of Bombay have been classified into eight different types according to the physio-chemical properties of the soils and subsoils (Basu and Sirur 1938). Such soil differences present special problems to the breeder as well as to the agronomist, in determining suitable crop types.

The principal climatic factors affecting crop production are, the *rainfall (water)*, temperature, light and wind. The breeder has also to build up crop types resistant to special climatic conditions such as frost, drought, flood, salinity caused by in-rush of tidal creek water etc., occurring in different regions and affecting crops adversely. Very often a set of climatic factors bring about special conditions favourable to the development of plant diseases, parasites or pests causing havoc with the crop concerned (Whyte 1947). Consequently the breeder has to assume the onerous task of building up types, either resistant to or escaping the trouble. The improved types of Dharwar-1 cotton which had practically covered the Karnatak cotton area (Kottur 1920), has to be replaced by the wilt resistant cotton type, Jaywant to combat the wilt menace, which had developed seriously in this region (Prayag 1942). Similarly a rust escaping early type of wheat, known as ' Jaya ' and a partially rust resistant early, synthetic type known as Niphad-4 have been bred in Bombay (Kadam and Kulnarni 1938 and Kadam 1944).

Certain adverse factors of crop environments can be neutralised by reproducing artificial conditions, yet in order to have economic results, the breeder has often a very limited scope in his agronomic manipulations, particularly in extensive cultivation.

Let us see how the present day breeder has been busy in finding his way through the maze of obstacles presented by the vagaries of crop environments.

A large number of plant breeding stations opened in the heart of typical regions, largely growing local varieties of a crop, generally yield economic selections suited to the respective regions, since the local varieties are the long standing survivals of the region, and present enough variability to afford scope for selection. At present Bombay has about fifteen such breeding stations for the crop of rice alone.

By acclimatisation of introduced types, by recent methods of selection and hybridization, and by taking advantages of heritable variations the breeder is making steadily a headway. Side by side with breeding operations, agronomic experiments are being conducted at the stations to ascertain the requirements of seed rate, spacing, manuring, watering, rotation, cutural methods, sowing time etc., of the improved crop types.

District trials of the best promising strains are conducted in cultivator's fields in comparision with the local variety, to verify their suitability to regions which they are expected to serve. Besides, improved types evolved at one station are tested at other stations where they are likely to be suitable. Improved strains of crops are maintained pure ; they are multiplied stage by stage ; and suitable areas are covered through well organised seed multiplication schemes for the benefit of the growers.

Necessary help on a very modest scale is being received today by the Plant Breeder from other technical sections, which are intimately connected with Agricultural Research.

With all these activities of the breeder, are we satisfied with the present progress of plant breeding work to fulfil adequately our need for the evolution of suitable crop types?

The following items need serious consideration in this respect :—

So long the plant breeder seems to be mostly engrossed in the study of purely morphological and growth type characters, with very little regard to the physiological characters of the plant. However, the following observations are very interesting :—

Homozygous derivatives of a complex cotton cross at Dharwar behaved differently under different manural treatments, millet strain tried in Kurnool and Cuddapah districts in Madras, gave differential response of the same strain at different centres (Swamirao and Subramanyam 1936) Hancock (1944) found that genetically independent lint properties in cotton varieties were greatly influenced by environments. Similarly in rice, scentedness which is a gene controlled character (Kadam and Patankar -938) is observed to be modified by environments.

The above cases indicate that agronomic trials of promising strains, at Research Stations as well as in the districts, will have to be introduced much earlier in the breeding programme of a crop. Such a procedure will determine the wider applicability of an improved strain, and the problem of spreading and popularising a strain in suitable extensive zones, will be much simplified.

Collaboration between meteorologist and plan breeders in making phenological observation on the relation between weather and behaviour of plants are likely to establish, in the long run, correlations between seasonal trends in the environment and growth behaviour of a plant. Laboratories for crop weather observations need be permanently established at all important research centres for principal crops.

Breeder's hands need strengthening by technical help from specialist such as the Chemist, Physiologist, Cytologist, Pathologist, Entomologist, Statistician etc All round improvement of a crop is not possible in the absencee of such help.

Since improvement by breeding is the cheapest, scientific method of permanent crop improvement, the breeder richly deserves, every help in his ever-lasting struggle with crop environments to ensure his success.

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THE NEED FOR BREEDING CROP VARIETIES ADAPTED TO VARYING LEVELS OF SOIL FERTILITY AND SPECIAL CONDITIONS OF SOIL AND CLIMATE.

If we take the example of Rice crop in Bengal, the breeding work was first taken up at Dacca now East Pakistan. Some high yielding strains were evolved there, but on extensive test all over Bengal, it was found that they were suitable only for East Bengal and part of North Bengal. Selection work was therefore started also at Chinsurah for West Bengal as part of Dacca work. The problem of West Bengal being totally different and requiring intensive study special staff were appointed in 1932 with financial aid from I.C.A.R. and two Rice Research Stations—one at Chinsurah and the other at Bankura came into being. These two Research Stations have since been the main centres for Rice Research in West Bengal, the former to tackle the problems of alluvial tracts and the latter of Red lateritic tracts.

Large number of types have evolved by these Research Stations to suit different tracts and situations which lie within their scope, but these are also not adequate for all the conditions prevailing even in the small province of West Bengal, if maximum outturn is to be obtained from every place by taking full advantage of local potentialities.

The soil and climate conditions under which Rice is grown from times immemorial are so numerous and diverse that already the crop has undergone good deal of natural selection giving rise to district physiological and cultural varieties which are suitable for particular conditions and cannot be interchanged, or any particular type be universally adapted. The main physiological groups in West Bengal alone are Aman, Aus and Boro. Aman is the paddy which is harvested in Winter, Aus in autumn and Boro in spring. Aus and Aman are again sown broadcast or transplanted according to conditions and nature of soil and the type of Aus or Aman which is suitable as broadcast crop may not be suitable as transplanted and *vice versa*. The alluvial tracts, the red laterite tracts, the saline tracts and the hilly tracts of the province again have different and specialised classes of rice only suitable to those tracts.

The Rice crop of West Bengal alone therefore shows that there are great variations in soil, climatic factors etc. and to evolve high yielding and better quality rice it is necessary to breed strains adapted to the verying levels of soil fertility and special conditions of soil and climate. The same is also applicable to all crops in every country if it is desired to materially increase the production of food and other commodities.

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SUBJECT No. I

SOIL FERTILITY

(*Note by S. Sen, Division of Agronomy, I.A.R.I.*).

The major factors determining fertility of the soil are : texture and structure of the soil, water supply, air supply food supply, organic matter content, soil reaction, depth of soil permanence of soil layer, absence of injurious substances light and temperature. Other factors which have not direct bearing on the soil fertility, but appreciably affect production are: variety of crops and incidence of diseases and pests. The agricultural practices which are important as means of maintaining soil fertility are : cultural operations, rotations of crops and maintenance of live stock related to different systems of farming.

There is a marked interaction among these factors, as the effect of one is considerably modified or controlled in the presence or absence of others as discussed later in this note.

Texture and structure of the soil

The proportion of soil particles, such as sand, silt and clay and the nature of organic matter present determine the texture of the soil, while the arrangement of these fractions determine the structure of the soil. Clay particles are active both physically and chemically and hence are of great importance to the fertility of the soil. The percentage pore space is also more in clayey soils than sandy soils.

The air-water relations of the soil are dependeent upon soil structure. Aggregation of soil particles into compound or crumb structure has great practical value on soil tilth and crop production. The distribution of pores in these soils are such that there are large pores between the aggregates to permit drainage and gaseous exchange between the soil air and the atmosphere and finer pores inside the individual aggregates for the soil to hold water for the use of plants.

Among the factors affecting the structure of the soil, the following have been found to ameliorate soil aggregation (a) presence of organic matter, (b) cultivation operations when the moisture content falls within a certain fairly narrow limit (c) growing of grasses and legumes, (d) presence of lime (e) proper drainage, (f) alternate wetting and drying.

The factors responsible for the break down of aggregates are cultivating the soil when too wet or too dry, (b) water logging, (c) rain, (d) irrigation and (e) frequent applications of soda and potash fertilizers.

Water supply

All the chemical changes which take place in the metabolism of the plant are carried out in watery solution. For this reason, water is an indipensable constituent of the plant, the growth of which is dependent on the amount of moisture present in the soil, The soil moisture in humid areas is controlled by the addition of organic matter, drainage and cultivation. In drier regions, following and irrigation have been found to be effective.

Air supply

Plants must breathe in order to ove. By respiration in its typical form is understood the oxidation of organic material to carbon diaxide and water ; this involves the absorption of oxygen by all plant organs from the air. Aeration also promotes the activily of soil organisms.

The tillage operations facilitate air supply in the soil to a certain extent by increasing the pore space. In irrigated tracts, the breaking of crust after watering promotes aeration. In well drained areas, pore space increases to some extent as a result of drainage. Earthworms have also been found to facilitate aeration and drainage.

Food Supply

A large number of elements have been found necessary for the healthy growth of plants. Those needed in large quantities are referred to as major elements. They are : carbon, nitrogen, phosphorus, calcium, magnesium, potassium, and sulphur. Elements needed in small amounts, usually referred to as minor or trace elements or micro-nutrients are : iron, manganese, boron, flourine, iodine, chlorine, aluminium, zins, cobalt, nickel and molybdenum.

Functions and intake of the major elements

Carbon.—It constitutes about one half of the dry weight of the plant and is taken up in gaseous form of carbon dioxide from the air by the green leaves. In the assimilation of carbon dioxide, soluble, carbohydrates are formed in the presence of green chlorophyll under the influence of sunlight with the liberation of oxygen.

Nitrogn.—It comprises from 40 to 50 per cent of the dry matter of protoplasm and for this reason, it is required in large quantities for all growth processes in plants. Without nitrogen, plants remain stunted and undeveloped. Nitrate is the normal form in which nitrogen is absorbed by plants from soils, although ammonia can also be utilised. Nitrogen availability is intimately connected with the activities of soil organisms. Nitrogen in organic compounds is converted into nitrate by a chain of reaction brought about by organisms. Ammonia may be held in the colloid complex as an exchangeable base in the same way as calcium, magnesium and potassium. The leguminous plants canutilizes atmospheric nitrogen through the help of symbiolic bacteria which infest the roots of the host plant. The bacteria penetrate through the

root hairs into the cortex of the roots and there give rise to nedules or tubercles. The bacteria live on carbohydrates and at first also on albuminous substances supplied by the host plant.

Phophorous.—This element is intimately associated with the vital growth processes in plants as it is a constituent of nucleic acid, and nuclei in which this occurs are essential parts of all living cells. Phosphorous is also of importance in seeds and in connection with the metabolism of fats. Compound of phosphorus are concerned with the processes of respiration and with the efficient functioning and utilization of nitrogen. Phosphorus is also of special importance in the precesses concerned in root development and the ripening of seeds and fruits.

Phosphorus exists in the soil in many forms, both as organic and inorganic compounds. Water soluble forms are generally most readily available to plants, even though they are rendered insoluble almost immediately after application to the soil. Organic forms of phosphorus are usually less readily available than the inorganic compounds, Phosphates undergo many charges in soils both by organisms and by purely chemical reactions and, even though very heavy dressing are applied, the amount of water soluble phosphate in the soil at any time is very small.

The movement of phosphates in soils is very limited, and soils are said to have high fixing powers for phosphates. Heavy soils show higher fixing powers then light ones, and soils with high iron content possess specially strong fixing properties. The two elements mainly responsible for the fixation of phosphates are calcium in neutral and alkaline soils, and iron in acid soils.

Important practical points in connection with the fixation of phosphates are that a large proporation of the phosphates added to many soils never become available to the crops, and that phosphates should always be placed as near as possible to the root of the plants.

Calcium.—One of the main functions of this element is as a constituent of the cess wall, the middle lamella of which consist largely of calcium pectate. Calcium also provides a base for the neutralisation of organic acids. It is concerned with activities of growing plants, especially with root tips.

Calcium occurs in soils in a large variety of minerals. The element is readily leached from the soil in humid regions where dressings of lim or lime stone are necessary. Calcium carbonate is readily brought into solution in soils by means of carbon dioxide dissolved in the soil water and thus a supply of calcium in soluble form is readily assured. Calcium also comprises the major proportion of the elements held as exchangeable bases where soils are not strongly acid and it is readily brought into the soil solution from this state.

Magnesium.—It is a constituent of *chorophyll* and is essential to the formation of this pigment. Magnesium is also regarded as a carcer of phosphorus in the plant. It occurs in the soil as carbonate. Like colcium it is readily brought into the soil solution from the carbonate, and is held in soils as an exchangeable base.

Potassium.—Unlike other major elements, potassium does not enter into the composition of any of the important plant constituents. It is present in all part of plants in large proportions. It seems to be of special importance in leaves and at growing points.

Among the functions which have been attributed to potassium and the processes with which it may be concerned, the following may be mentioned : the formation of carbohydrates and protiens ; regulation of water conditions within the plant cell and of water loss by transpiration; as a catalyst and condensing agent of complex substances ; as in accelerator of enzyme action ; as contributing to photosyntheses through its radio active properties. The liability to disease is diminished by supplying potash.

Potassium is widely distributed in soil minerals such as potash felspar, mica and glauconite, from which it is slowly converted into soluble forms by weathering process. Heavy soils contain higher amounts of potassium than light soils. Potassium is fixed in soils, possibly as an exchangeable base which appears to be readily available to plants.

Sulphur.—It occurs in plants as a constituent of protein and of certain volatle compounds such as mustard oil. It seems to be connected with chlorophyll formation although it is not a constituent of this substance.

Sulphur is present in soils both in organic and inorganic forms. Inorganic sulphur is mainly present as sulphate. Sulphuric compounds are changed from one form to another in the soil by special bacteria, the end product of whose reactions is the sulphate form where conditions favour oxidation.

Minor elements

The minor or trace elements serve three purposes, viz., (1) catalytic, the promotion of oxidation or other essential reactions, (2) stimulative, the setting in train of differentiations or other processes vitally important to the plant and (3) prophylactic, protecting the plant against disease.

Organic matter content

Plant residues, either naturally or artificially added, provide the main source of organic matter in soils. These residues vary greatly in character and composition, depending on the plants from which they are derived. In addition to plant residues soils organisms and animal remains contribute to the organic matter.

In the soil the fresh material undergoes chemical change, especially by the action of soil organisms, and when this has proceeded to the stage where the original cellular structure is no longer recognisable, the brownish product is termed as humus. The organic matter in the soil at any time thus consists of resh and partly decomposed residues and humus.

The carbon nitrogen ratio is usually high for the crop residues of most non-legumes. In the decomposition of such residues, carbon losses are high unless there is an adequate supply of nitrogen. The use of nitrogen with carbonaceous crop residues to build organic matter and nitrogen reserves varies widely under different conditions.

The main effects produced by humus on the soil are :

(1) It gives a brown or black colour to the soil, unless much calcium carbonate is present.

(2) It increases the retertive power of the soil for dissolved substances.

(3) In the presencee of calcium carbonate or of sufficient exchangeable calcium, it does not wash down in the soil, but remains fixed in the surface. In the absence of sufficient calcium however, it becomees dispersed and washed down to a certain depth.

(4) It causes the soil to become puffed up and so leads to increase in the pore space.

(5) It increases the water holding capacity of the soil.

(6) It swells when wetted.

(7) It increases the biological activities going on in the soil. The soil organisms play a very important part in determining the availability if minetral nutrients in soils by breaking down plant residues and also by providing carbon dioxide which, in combination with water, is of great importance for the weathering of the soil minerals.

Soil reactions

Three possibilities have been studied as to the actual cause of the injury to plants on acid soils.

(1) Direct injury by the acid (hydrogen) irons.

(2) Soluble aluminium compounds resulting from acidity of the soil.

(3) Lack of calcium.

Liming offers a means of improving the acid soils.

Depth of soil

The layer of soil in which plant roots can develop freely is deepened by the following methods.

(1) Drainage, where the water table limits root development.

(2) Deeep ploughing or subsoiling to break up a compact layer or plough pan. This appears to be effective only where organic matter is added to the freshly broken lower layer.

(3) The growth of deep rooting crops, the roots of which can both penetrate the subsoil and on dying, enrich it in organic matter.

Permanence of the soil layer

In semi-acid regions, the soil remains fairly stable so long as it has some covering of vegetation, but it readily breaks down to dust if the vegetation is removed and the fibrous roots that held the particles together become oxidised.

Three methods have been particularly destructive.

(1) Over cultivation, especially alternate cultivation and of allowing with no period of rest in grass.

(2) Overstockings putting too many animals on the land, so that the vegetation was eaten down too rapidly to allow the cover to be maintained.

(3) Cutting down the forests and making no provision for regeneration or replanting.

In one and the same tract, erosion may take place both by rain and by wind, but there are important differences between the two agencies.

Erosion by rain storms.—The important factors at work are :

(1) The effective rainfall, i.e., the rain that runs off carrying soil with it.

(2) The vegetation cover, Erosion under cultivated crops is considerably greater than under forest of undisturbed natural vegetation.

(3) The effect of gradient. The velocity of run-off and therefore its transporting power naturally increases with the increase in slope of the land, but the amount of erosion depends also on the type of soil. Clay soils erode more than sandy soils at low gradients, but less at gradient above 15 per cent.

Methods of prevention include the encouragement of ground cover, the levelling of sites, the construction of berriers to break the velocity of run-off water and in hill districts the terracing or ridging of the land.

Wind erosion.—This occurs to some extent in all acid and semi-acid regions and it is intensified by the following that usually forms part of the agriculture systems there adopted.

To methods of dealing with the erosion have been used.

(1) The planting of trees to make wind breaks.

(2) Modification in the method of cultivation to minimise its ill-effects.

Absence of injurious substances

Over great areas of the world, where the average rainfall is less than 15 inches per annum, the soil is liable to contain appreciable amounts of soluble salts, notably sodium carbonate and the chlorides and sulphate of magnesium, sodium, potassium and calcium. Some of these particularly the chlorides, may directly injure the plant, others apparently interfere with the supply of water or of nutrients.

Plants differ in their sensitiveness, maize being very sensitive.. Those less affected include sugarbeet, barley, lucerne and sweet clover, which are therefore grown in cool alkali regions, and sorjhum, cotton, rice, berseem and date palm which can be grown in worm alkali regions.

The effect is much modified by other salts, notably calcium salts, that a harmful concentration of sodium chloride may become innocuous if calcium sulphate is added.

Cultural operations

One of the main functions of soil cultivation is to alter the size distribution of the aggregates that occur in the field. Well formed aggregates arise only within a fairly narrow moisture range which would maintain a correct air moisture relationship in the soil for normal growth of crops.

The destruction of weeds is another important object attained by careful tillage operations.

The various cultivation processes are commonly supposed to exert a great effect on soil aeration, and they facilitate renewal of the soil air and increase the total volume of air in the soil by increasing the pore space. This also results in increased bacterial activity in the soil.

Tillage is also concerned with the relationship of soil to the moisture it contains in many respects. By appropriate cultural operations, it is possible to prevent loss of water by evaporation and conserve moisture for the use of growing crops or to render moisture in the lower depths of the soil available near the surface. Further cultivation operations facilitate drainage of water and thus the water supply of the soil.

The C|N ratio falls when virgin soils are broken up and converted into arable land, the carbon being lost more quickly than the nitrogen.

Exposure of the soil to the baking heat of the sun by summer cultivation increase fertility of the soil due to partial sterilisation, as it has been found that micro organisms surviving partial sterilisation produce more ammonia and nitrate than the original population.

Crop rotations

A rotation of crops is more effective for the maintenance of soil fertility than a system of continuous cropping. The inclusion of a legume in the rotation for fodder or seed or for use as green manure is a well established practice for the maintenance of soil fertility. Fallowing also causes marked increases in the nitrate content of the soil and keeps down weeds.

The old method of replenishing soil fertility was to alternate the periods of arable cultivation with a year's rest when the soil was left to cover itself with wild or self sown plants which were then plough under. One of the greatest improvements in agriculture has been substitution of a definite sown crop of selected grasses and legumes, especially clovers for the indefinite mixture of selfsown plants. The ley farming or alternate husbandry in which a mixture of grass and legume is grown for herbage for several years and then put down to arable crops has been incorporated in the agriculture of different countries with remarkable success.

The practice of mixed cropping, in which legumes mixed with non-leguminous crops are grown on the same land, has sometimes shown better results than when the non-leguminous crops are grown alone. There is some evidence that during the growth of certain leguminous plants, nitrogen compounds are exerted from their roots and from these compounds, adjacent plants can in certain circumstances benefit.

Maintenance of live stock.

Under normal conditions, livestock contribute to soil fertility in three ways :—

(1) They convert the feeding stuffs imported from outside into plant food.

(2) They convert the indirectly cashable products of the farm into plant food.

3. They add humus to the soil.

Assessments of soil fertility

The signs of low fertility of a field are stunted growth and sparseness of the crop and marked patchiness or variability in the height of plants. The methods of determining mineral deficiencies have been developed along the following lines:—

(1) The chemical analysis of whole plants or parts of plants.

(2) Field and pot culture trials to determine the effects of withholding or adding mineral nutrients to the soil.

(3) Soil analysis to ascertain the supply of nutrients in the soil.

(4) The addition of mineral nutrients direct to the plant by injection and spraying methods.

(5) Visual methods of diagnosis based on defficiency symptoms shown by plants.

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Subject 1.

THE NEED FOR BREEDING CROP VARIETIES ADAPTED TO VARYING LEVELS OF SOIL FERTILITY AND FOR SPECIAL CONDITIONS OF SOIL AND CLIMATE.

Soil and climatic conditions are found to vary considerably from place to place even in the Province in India. These affect considerably the vegetative growth and production of most of the crop plants and the existence of agriculture or cultivated varieties in different crops is the outcome of such variations.

Experience gained in the evolution and spread of improved varieties of crops especially of oil-seeds has shown that strains bred and evolved under particular conditions or from particular variety of one locality are not suitable for certain other situations where the environmental conditions are quite distinct. The contributory factors may be the difference in the fertility, texture or other conditions of the soil, rain fall, temperature, length of the day, etc. In groundnuts, varieties with short duration have to be bred in areas where the favourable growth period of the crop is short and drought resistant varieties in tracts where the rainfall is precarious. In gingelly, the climatic and soil conditions are found to assume great prominence and influence, growth, flowering time, duration and yield. Most of the gingelly varieties are season bound and suited only to particular localities. When some of these varieties are grown in other localities or seasons they put on only vagetative growth and never flower or fruit. In caster also, duration is considerably affected by rainfall and a variety which mature. in 7 months in a dry area may take about 10 months in a more rainy tract. Thus there is great need for evolving strains suitable for different tracts and this is best done by dividing the Province into definite zones or regions with reference to different crop, seasons and soil conditions and breed varieties in Regional stations.

AGRICULTURAL DEPARTMENT,
15th December, 1947.

C. M. JOHN,
Oil-seeds Specialist.

CROP—RICE.

Subject 1(*a*).—Breeding varieties of crops adopted to varying levels of soil fertility and special conditions of soil and climate.

The rice area in Madras Presidency may be broadly grouped into the following zones :—

1. The Delta system of the Godavari and Kistna.
2. The Cauvery and the Coleroon system.
3. The intensive garden land cultivation practised on the North Arcot, South Arcot, Chittoor and Madura districts.

4. The smaller irrigation systems of the Nellore and Tinnevelly districts.

5. The tract dependant upon the rainfall comprising—

(i) The heavy rainfall tract of the West Coast ; and

(ii) the East Coast districts.

These zones have distinctive features of rainfall (amount and its distribution) and climatic factors. The soils are variable from the pure sandy areas to heavy black clays. Even in each of the tracts mentioned above the conditions of soil and situation of the fields as regards retention of water, etc.. are available. Through a system of natural selection and also through human agency a large number of varieties came into existence to suit the diverse conditions. Especially in rice, it has been found that "*variety*" has a great significance and there are therefore some varieties which ripen off in 80 days while others take 200 days. (The latter are grown with red gram as mixture and also under submerged conditions). The Madras Department of Agriculture as part of the co-ordinated policy opened rice research stations in the different tracts as it was found that the strains evolved at one station were found unsuitable to other tracts.

The question, whether strain swithin a particular group have differential yield responses to variations in soil fertility, has not been very intensively studied. Experiments in foreign countries have however, shown that strains even within a particular group possess differential capacity to make use of 'nutrients' to different degrees, which may, therefore be reckoned, as Mendalian in character. Experiments to test this truth are being studied in some of the Rice Breeding Stations in Madras.

Breeding for special conditions of soil.—These include such conditions as (i) submergency, (ii) open or dry conditions of soil as opposed to swamp, (iii) alkalinity, salinity and acidity.

It is obvious that special varieties have to be bred for these different conditions. On these types of soils which are found in different parts of the Madras Province, certain varieties, are being grown. They should have arisen by process of natural selection. These varieties generally are poor yielders. Any improvement in the varieties by breeding methods should proceed on the supposition that the resistance of such varieties are hereditary and as such could be combined with yield. The studies on this aspect of resistence of the varieties should involve a knowledge of related branches of botanical science such as physiology, anatomy and also particular branches of chemistry. Inheritance studies so far made indicate, that these characters through recondite, do mendelize. A concentrated approach to this problem by the anatomist, chemist physiologist and the breeder should be helpful to breed improved varieties and strains to suit the special adverse soil conditions.

Taking for instance one aspect of the special conditions, *viz.*, draught resistance into consideration, it is seen that this requires a

thorough knowledge of the physiology of the plant in its special relation to water requirements at different stages of its growth, osmotic pressure of cell sap. the chemistry of the cell sap and its colloids. There are varieties which give very heavy yields under 'dry' conditions, under heavy rain-fall and good manuring. The root studies, etc., of such types are important and methods of studying roots of rice *in situ* have yet to be perfected.

Diseases and climate.—In some parts of the country, certain diseases, as for instance *blast* on rice, are epidemic—appearing. in particular seasons only and this shows that the atmospheric conditions have a very pronounced effect as the incidence of the disease. The disease assures terrific form in certain seasons and considerable losses result. Absence of the disease should not lead one to the belief that the tract has no disease and it should be realized that it is only the want of optimum whether conditions that had prevented the disease from appearing. Under these conditions, it is only the plant breeder, who could help the industry by evolving strains of crops which are resistant to diseases. That such achievements are possible and has been borne out by the evolution of blast resistant strains in the Madras Presidency. This aspect of the question has to be seriously taken up and should appeal as a method of crop insurance.

Even the building up of varieties of crops resistent to pests comes up under the purview of the plant breeder. The jassid resistant U. 4 cotton which pest threatened to swamp cotton growing in Uganda is a case in point.

Subject 1(b)—Maintenance of soil fertility.—As far as paddy soils are concerned, the review of all literature so far available would point out that the growing of green manure crops is the best method of maintaining the soil fertility. All methods such as supplying water for growing green manures wherever possible. giving subsidy, for growing green manure crops, making available green manure seeds at places within easy reach of the cultivator, etc., may be thought of to encourage raising of green manures. Crop rotations which include a pulse for grain or green manure have beneficial effects upon the subsequent paddy crops. Groundnut was found to increase the subsequent paddy crop. In the paddy soils under puddled conditions, it has been found that with adequate manuring with green leaf or green manuring *in situ*, the soil is not depleted by continuous cropping of even two crops in the year. Peculiarly applications of composts up to 10 tons did not secure increased yields in the case of puddled paddy soils.

Soil fertility and quality of crop production.—'Quality' as far as paddy is concerned, is an elusive term. Different people have different interpretations of quality in this cereal. The idea of quality of the miller which means the percentage of outturn of rice to paddy is different from that of the producer who wants more price for his produce irrespective of other considerations. This is in conflict with that of the consumer who wants the biggest volume of fluffy, palatable

cooked rice. This is obviously different from that of the nutritional experts' view of quality which presupposes a nutritional balance with the largest protien content. But it is presumed that quality in the Agenda means the last view (nutritional). Literature on the influence of soil fertility on nutrition value of crops does not seem to be extensive even in foreign countries and much less so in India as far as rice is concerned. Preliminary work conducted in the quality of rice from the historical aspects at Coimbatore, sometimes ago, has shown that (1) under manured conditions the aleurone layer is better developed than under unmanured conditions. (2) In varieties grown under irrigated (swampy) conditions, the aleurone layer is thicker than the same varieties grown under ' dry ' conditions. (3) Coarse rices contain thicker bran layers than fine rices. Dr. Srinivasan, who made investigations on this aspect from biological point of view, confirmed the above. Thus manuring and irrigation which secure more nutritious rice as also volume of crop, should have the highest priority in the national building activities of the country.

M. B. NARSINGA RAO,
Paddy Specialist.

[*Subjects*].

Item 1 (a)—*The need for breeding crop varieties adopted to varying levels of soil fertility and special conditions of soil and climate.*—Differences in soil fertility should not stand in the way of developing common varieties since the varieties could always be corrected by applications of manure in regions served by well or canal irrigation or regular but adequate monsoons. A multiplicity of varieties must be avoided as far as possible and the work concentrated on improvements in soil management rather than breeding varieties having limited adaptability. Otherwise maintenance and distribution of improved seeds or the large scale production of commercially uniform quality would become almost an impossible task. In regions where shifts in planting time or cropping systems can successfully counteract climatic vagaries or disadvantages, they must be fully experimented with, before trying to fit in special varieties.

In cotton, strains suitable for greater environmental diversity have been built up for both irrigated and unirrigated conditions. A wider hybridization programme involving the use of varieties subjected to long spatial and ecological isolation is likely to yield the required variability for applying selection to achieve this end. The utilization of hybrid vigour will to a very large extent serve the same purpose, especially in self-fertilized crops producing a large number of seeds per fruit.

Item 1 (b)—Review of work done on the maintenance of soil fertility in India with suggestions for future lines of work with particular reference to the effect of soil fertility on the quality of crop production.—The problem of leaf reddening, physiological shedding of flower buds and development of fibre immaturity in cotton are related closely to soil fertility especially nitrogen. The phenomenon of hollow seeds in South Arcot district results in poor germination and continued imports of seed for sowing from other areas. It appears to be due to soil defect. Low fibre maturity in cotton raised under restricted irrigation of black soils in Tungabhadra Project is another defect which has so far eluded solution Moisture is unlikely to be a limiting factor since the cotton produced under unirrigated conditions in the same area possessed higher maturity. Both these tracts require intensive studies.

R. BALASUBRAMANYAM,
Cotton Specialist.

MADRAS AGRICULTURAL DEPARTMENT,
10th December 1947.

Subject No., 1.

The need for breeding crop varieties adapted to varying levels of soils fertility and for special conditions of soil and climate.

Note by

Sardar Bahadur Sardar Harchand Singh, Commissioner for Agriculture. Patiala.

Breeding of crop varieties adapted to the varying levels of soil fertility and for special condition of soil and climate is the most important work that research in agriculture has done for the good of the country. It does not require any argument to prove that there is the greatest need for this work. The evolution of the Coimbatore canes has changed the outlook of the Sugar Industry in India. In Patiala the indigenous variety of cane used to give an average yield of 300 maunds of cane per acre. Now the yields from the Coimbatore canes is on average 800 maunds of cane while with special care it can give more. His Highness Shri 108 Maharajadhiraj Mahendra Bahadur of Patiala has been able to get 1600 maunds cane per acre by the good preparation of seed bed, at his Bahadar Garh Farm.

Similarly the results shown by the new varieties of wheat, Cotton and rice are wonderful. There is still a great room for further improvement, in the case of all above and in fact of all the crops. The work of breeding can be done at the research stations managed and supported by the Governments both Central and Provincial and States as the conditions varies from place to place. The work done at one place may not meet the requirements, hence the work should be continued in the provinces and states where it is going on and started in the Provinces and States where it has not been taken so far.

Subject No. 1.

The need for Breeding Crop varieties adapted to varying levels of soil fertility and for special conditions of soils and climate.

By

R. B. Ekbote and D. R. Dhodapkar, Wheat Research Station, Powarkhera, C. P. and Berar.

In India as a result of the considerable amount of plant breeding work carried out so far, promising strains have been evolved in most of the important crops. In all cases, however, strains have not been developed to suit specific level of soil fertility. More often than not, attempts were made to breed strains under conditions approximating to those obtainable on a common holding *i.e.*, of average soil fertility. Even, then the breeders off and on were criticised that their experimental plots were of a higher order of fertility and received more intensive cultivation than the land of average farmer. The breeders argued, and in most cases in vain, that high yielding varieties must need a higher uptake of nutrients and in order that full advantage of the improved strains be taken attempts must be along side made to enrich the soil by judicious manuring and through cultivation. The fertility of Indian soils as could be judged from the yields of no manure plots of over 5000 experiments, has established at a low level and constitutes the limiting factor in crop production. This fact was more fully appreciated in recent years when the need for stepping production of food grains came to the forefront. At the fifth meeting of the Crops and Soils Wing of the Board of Agriculture, a considerable discussion took place on the subject of maximum potential of different soils and it was unanimously agreed that the required information not being available, experiments be laid out to find out the maximum producing capacity of the soils at different experimental stations. The same may be said regarding crop strains. That field has not been explored. The fact that the response of different varieties to varying doses of manure is not the same can be demonstrated from the results of some of the manurial-cum-varietal trials. In C.P. and Berar the performance of Pusa and local Wheat varieties was

compared at two different levels of manuring and the following results were obtained, during the years 1920-30 :—

Station—Labhandi Farm, Raipur.

Yields shown as percentage increase over control.

Varieties	A Unirrigated & unmanured Lbs.	A Unirrigated & unmanured Percentage	B Irrigated & manured (240 lbs. cake per acre) Percent.	C Irrigated and manured (400 lbs. cake per acre) Percent.
Pusa 52	437	100	147	165
53	447	"	129	170
100	441	"	140	148
101	463	"	141	154
AO 89	444	"	142	131
" 90	437	"	117	114
" 113	491	"	117	132
" 115	492	"	129	130
Kathia	387	"	108	75

The Pusa varieties in general show a greater response to manuring although no significant difference is descernible in their yields in the control plots.

A similar response to irrigation and manuring has been observed in different varieties in another experiment conducted at Powarkhera Farm during the years 1943-45.

Yields shown as percentage increase over control.
(under irrigation).

Variety		Control No manure	10 Lbs. per acre through AM Sulphate	No. 10 lbs. N. through Niciphos	20 Lbs. N. through A.M. Sulphate	20 Lbs. N. through Niciphos
AO	13	100	170·3	167·7	159·5	164·0
N. P.	101	100	109·1	116·2	117·5	125·2
A	118	100	113·7	112·8	101·8	109·9

The greater response of AO 13 to manure is clearly brought out, in these results. The results of another experiments also indicate that

the reaction of different crop varieties under varying doses of manure is not the same. It then follows that in order to aim at maximum productions under differing levels of soil fertility, there is need to evolve strains as would give the best performance under a given soil condition. The levels of fertility must, however, be broad-based.

Subject 1(b).

Phosphate manuring of legumes for building up soil fertility.

By

S Sen,

Indian Agricultural Research Institute, New Delhi.

A—Review.

Dr. A. B. Stewart (I) in his report on "Soil Fertility investigations in India with special reference to manuring" has reviewed the past experimental work of this country, the main conclusions of which are quoted below :—

1 *Manures and fertilisers.*

(1) *Nitrogen* (*N*) :—Although conflicting results have often been obtained regarding the amount of nitrogen to be applied, the relative merits of nitrogen in different forms, the time of applying nitrogenous manures, the great majority of the experimental results do agree in demonstrating that nitrogen deficiency is extremely widespread in the soils of India.

The fact that crops differ in their nutrient requirements is well illustrated by experimental findings on the response to nitrogen shown by different crop. With sugarcane, for instance, good results have been obtained from the application of dressings supplying about 300 to 400 lb. N per acre on the medium thick canes of long-growing period in Peninsular India, whilst with the thinner cane of shorter growing period, which is common in northern India, the nitrogen requirement is correspondingly less. For cotton, and for cereals such as wheat or paddy, dressings supplying some 40 lb. N per acre appear to give quite good results under irrigated conditions. From the very few results available from manurial experiments on country tobacco, it appears that a useful response may be obtained from the application of nitrogen at the rate of anything up to 60 or 80 lb. N per acre. For jute there are likewise very few reliable experimental results but a dressing at the rate of about 20 to 30 lb. N per acre has been indicated in certain soils. Where lack of water is a limiting factor in crop growth, full response to the application of manure cannot, of course, be expected. For cotton and wheat grown under rain-fed conditions, past experiments suggest that nitrogenous dressing should be

at only about half the rates given above for these crops under irrigated conditions. For other crops such as the millets, which are commonly grown under rain-fed conditions, dressings at the rate of about 15 to 20 lb. N per acre appear to be indicated.

(2) *Phosphate (P)*.—There have been numerous experiments in which the application of ordinary broadcast dressings of phosphate has failed to show a response, but many conflicting results have been obtained, for a deep-rooted plant like cotton. There is no evidence from past experimental work that the application of Phosphate is beneficial. On the other hand the shallower rooted wheat crops, in certain parts of the Punjab, has shown a response to phosphate in areas where no response was obtained with cotton. The results for paddy emphasize the importance of soil type in relation to response to phosphetic manures. It is commonly found in many areas where phosphate by itself has little effect on yield a combination of nitrogen and phosphate may be markedly superior to nitrogen alone. The importance of the phosphatic manuring of legumes, as a means, not only of increasing the yield and feeding quality of the legumious crop as such, but also of improving general soil fertility and thereby permitting of a far more efficient and intensive utilization of agricultural land especially under conditions of adequate irrigation, has been ably demonstrated.

Apart from a few experiments with ammonium phosphate, most of the experimental work on phosphate in India has been done with superphosphate and with bone products, and the results suggest that, as could be expected, the former is rather quicker-acting than the latter.

(3) *Potash (K) and combinations of N.P. and K*:—The general experimental evidence appears to suggest that most Indian soils, apart from the laterites, are relatively well supplied with potash, and that for most crops there is little need for potassic fertilizers. Tobacco, chillies and certain fruit trees are crops which are exceptional, in that they have shown responses to experimental dressings of potash under a variety of soil and climatic conditions. There are numerous instances of experiments in which the application of potash by itself has not only failed to show a positive response, but has even caused a reduction in crop yield. The response to potash in the presence of adequate supplies of other plant foods is, however, by no means clear. Although it is clear that, in most of the areas in which experiments involving potassium have been carried out, the potassium supplies in the soil have been relatively more satisfactory than the nitrogen supplies, there are comparatively few experiments in which the combination of treatments studied permits of information being obtained, either on the absolute potash contents of the soils or on the probable response to potash at varying levels of other nutrients. From the phosphate manuring experiments it was seen that there are many instances where phosphate alone was ineffective, but where the application of phosphate together with nitrogen considerably enhanced the beneficial effect of the latter. From the comparatively few experiments which have been carried out in different parts of India to study the effects of potash

at different nitrogen and phosphate levels, there is evidence that the same may hold good for potash. In many experiments where potassium either alone or in combination with phosphate has led to a reduction in yield its application in combination with nitrogen or nitrogen and phosphate has given a marked response over that given by nitrogen alone. From the comparatively few manurial trials on jute there is also evidence that NPK in combination is superior to either, N, P or K by itself, and also to combinations of N and P.

(4) *Bulky Organic Manures* :—Although many experiments have given conflicting results, the general conclusion, which may be drawn from the bulk of evidence, is that bulky organic manures do play a very useful part in the maintenance of soil fertility and in the improvement of crop yields. Amongst points of interest and of fairly wide application are the following (a) As a source of nitrogen, farm-yard manure is generally considerably slower in its action and less effective than equivalent amounts of nitrogen in more concentrated and readily available forms, such as ammonium sulphate or cakes. (b) Crops vary in the extent to which they response to dressings of farm-yard manure, *e.g.*, jowar is more responsive than either cotton or wheat. (c) In certain soils response to fertilizers may be enhanced if they are used to supplement basal dressings of farm-yard or similar bulky organic manures. (d) Variations can be expected in the value of organic manures of different origins, as may be seen from the results for maize, where sheep dung has shown up particularly well as a source of nitrogen.

Amongst other points of general importance emerging from past work on organic manures are the following :

The manurial value of farmyard and similar organic manures in the season of their application will depend on the degree of decomposition of the product. Relatively raw. undecomposed material may utilize precious water to aid its decomposition, and may also be responsible for a temporary shortage of nitrogen in the soil at a critical period in the life of the plant.

It is, for instance, well established that bacteria responsible for the decomposition of organic matter in the soil need nitrogen which will have to come from the soil in the absence of supplies from other sources Very little work has been done in India on the correlation of results on crop yields, feeding value of produce and soil properties, but it is nevertheless, claimed and believed by many that organic manures are superior to mineral fartilizers in the production of crops of higher feeding value. The existing evidence is quite insufficient to warrant any such generalization and, in this connection, it should be remembered that farmyard manure, produced by animals which have been fed on produce grown on a soil which happened to be mineral-deficient cannot by itself supply the deficient minerals.

Another method of supplying organic matter to the soil, which has received a considerable amount of attention in India, is that of green-manuring, the main requisite for the success of which appears to be the availability in the soil of sufficient moisture to ensure the

decomposition of the green crop after its inversion. The evidence to date suggests that about 5 to 6 acre inches of water may be regarded as the minimum necessary for the decomposition of an average green manure crop, and where this is assured green manuring has usually given beneficial results.

(5) *Lime* :—A limited amount of experimental work has been undertaken to study the effects of additions of calcium carbonate or calcium oxide on acid soils in different parts of India. In most of the experiments lime at relatively low rates supping the equivalent of up to about 1000 lb. Cao per acre have been studied, and there is a considerable amount of evidence in favour of such dressings. In Madras, however, the general conclusion from the experimental work which has been undertaken on the liming of some of the acid red soils is that, despite their acidity, the soils show little need for lime dressings. In many of the acid soils of paddy tracts in Bengal, lime is apparently without effect on the yield of paddy, but seems to have a distinctly beneficial effect on pulses or oilseeds which have been grown in rotation with it.

II. *Alkali or saline soil ameliorants.*

In the reclamation or improvement of alkaline or saline soils, the use of various materials not commonly used as manures in general agriculture is often found to be advantageous. Such materials include calcium sulphate or gypsum, calcium chloride, molasses and sulphur.

III. *Cultural Practices.*

(1) *Methods of cultivation or tillage* :—Although many conflicting results have been obtained in different parts of India, results such as those which have been obtained in the Punjab appear to be of fairly wide applicability. There, as in most parts of India, the principal cultivation operations depend on the ordinary desi plough, and furrow turning ploughs, mechanical hoes and other implements were largely unknown until their introduction by the Department of Agriculture. From fairly detailed experiments with those improved implements alongside the desi implements, the general conclusion in the Punjab is that, where the standard of normal cultivation by the desi implements is high, the use of the improved implements has no significant effect on crop yields, but does permit of a small saving in labour. Another observation which has been made in rainfall-defficient areas in many parts of India is that repeated shallow cultivations during the monsoon period do appear to be of value in conserving water for a subsequent rabi crop.

(2) *Rotations* :—Recent results in Central Provinces and Hyderabad have indicated a beneficial effect on cotton of the introduction of groundnut into the normal cotton-jowar rotation, and in various parts of northern India striking increases have been obtained in the yield of cotton following a phosphate manured crop of berseem. Again, in Madras and other parts of Peninsular India there are indications that bajra may be superior to jawar as a rotating crop for cotton. In the Lyallpur district where the cultivators themselves do not appear to follow any definite rotations, trials have been carried out on a series of three

year rotation at different intensities of cropping. When water and manure are available in sufficient quantitnes, an intensive rotation of wheat, kharif fodder, grain, cotton and senji is found to give good returns but, as could be expected, less intensive cropping is possible when water and manure are restricted. Other conclusions from these experiments are that (a) cotton does well after fallow and after gram, (b) wheat gives a good yield after senji, sugarcane and guara (Cyamopsis) green manured, (c) the yields of gram after fallow and after a kharif fodder are almost the same, and (d) a rotation of wheat, cotton and sugarcane, involving the application of farmyard manure to the cane crop, gives a good return. In Sind, chief attention naturally enters round the rotations most suitable for the irrigation system available. Whilst the official recommendation under the Barrage System appears to be a 5 Year rotation, the staff of the agricultural department favour a 4 year rotation, whilst the cultivators generally, by the omission of the final year's fallow in the 4 year rotation, appear to prefer a 3 year's rotation. These rotations generally involve kharif crops of rice, bajra, cotton and jawar, and rabi crops of wheat, oil seeds gram and lathyrus, subdivided further according to locality into two main groups of (a) cotton, jowar, bajra, wheat and oilseeds, and (b) rice, gram and lathyrus.

Phosphate manuring of legumes.

The results of experiments carried out at the Indian Agricultural Research Institute, New Delhi have shown how phosphatic fertilisers can improve the yield of legumes, increase the phosphate, calcium and protein contents of the fodder so produced and assist in the building up of soil fertility of a stable type by which high yields of cereals crops, such as wheat and maize following in the rotation can be ensured. The results of these investigations have been dealt with by Parr and Base (2 and 3). In this note a consolidated account is given of the striking results so far achieved at this Institute by using phosphates on legumes grown for fodder or green manuring.

The legumes need phosphate, whether it is available in the soil or added as a fertilizer, and the experience of other countries has shown that when this is provided, legumes respond well. Helz and whiting (4) in field trials with soybean found that phosphorous and potassium increased nodulation in soybean. Giobel (5) experimenting with alfalfa and soybean found a close correlation between the total mass of nodules developed and the amount of nitrogen fixed. Roberts and Olson (6) observed that the nitrogen content of several experimental plots on which a rotation including legumes was used, was higher where phosphatic and potassic fertilisers were applied than where no fertilizers were applied, inspite of greater removal of nitrogen by crops from fertilized plots. The gain in some cases due to the use of phosphorous and potassium was 40 lb. nitrogen per acre per year In green house experiments, fertilization of soybean, alfalfa and alsike clover with phosphate increased nitrogen fixation by as much as 30 per cent in some cases Alsike clover and alfalfa also responded to potassium when adequate supply of phosphorus were available. Poschenriender *et al.*

(7) in experiments with sand cultures in which the levels of K_2 and $P_2°_5$ furnished the soybean plant were varied, increasing $P_2°_5$ increased the nitrogen fixed at all levels of K_2. When $P_2°_5$ was at too low a level increasing the available K_2 decreased nitrogen fixation ; at more optimum levels of $P_2°_5$. increasing K_2 increased fixation. The mg. of nitrogen fixed per gm. dry weight of nodules was closely positively correlated with $P_2°_5$ content of the nodule and negatively correlated with the K_2 contents.

Since legumes and valuable nitrogen to the soil, and since the amount of nitrogen fixed increases with increase in the legume yield, phosphate manuring offers a method not only of increasing the yields of legume crops, but also of supplying Indian soils with the much needed nitrogen for the benefit of the succeeding food and cash crops, which need large quantities of nitrogen for high yields.

Both man and animal need phosphate. Along with calcium, phosphate forms a very important constituent of milk. The total output of phosphate and calcium by milch cattle is high and constitutes a very severe drain of their reserves. Phosphate and calcium entering in plant composition are probably more easily assimilated by the animal than when given in mineral forms.

In experiments conducted at this Institute under irrigated conditions, berseem (*Trifolium alexandrinum*) stands out as a highly efficient user of phosphate. The other legumes which have responded well to phosphate manuring are : *senji* (*Melilotus parviflora*), *Guar* (*Cyamopsis psoralioides*), *methra* (*Trigonella Foenum-graecum*), lucerne (*Medicago sativa*) and peas (*Pisum Sativum*).

Berseem in rotation with cowpeas and wheat.

In Table I are given results of the experiments of phosphate manuring on berseem at Delhi. Berseem was grown in rotation with cowpeas (unmanured) for three consecutive years 1940-41-42 ; no manures of any kind were applied after 1942. The subsequent cowpeas and wheat crops were grown on whatever fertility had been built up by berseem in conjuction with phosphate. In 1946-47, *guar* was substituted for cowpeas as the former was found to respond better than cowpeas.

These results show the striking effect of phosphate in increasing the yield of berseem and building up the soil fertility as reflected by high yields of unmanured wheat grown subsequently.

The phosphate and calcium contents of the berseem and cowpeas fodders, phosphate content of wheat grain and nitrogen and phosphate contents of wheat straw were also increased as will be seen from Table II. Though the percentage nitrogen contents in berseem and cowpea hay and wheat grain were not affected by the different treatments, the total nitrogen contents show marked increases over the control.

Berseem in rotation with maize and wheat.

Table III shows the yields obtained in an experiment conducted at Delhi to test the effect of phosphate in different forms on berseem and after effects on maize and wheat.

Here three unmanured cereal crops were taken after berseem which was manured with phosphates. Superphosphate was top dressed late owing to its late arrival and the results were not in conformity with those reported before when the fertilizer was applied at the proper time. The response of berseem to ammonium phosphate was very significant which shows that the addition of nitrogen with phosphate has good effect on the berseem crop. The subsequent yields of maize and wheat were also higher in plots in which berseem was fertilized with ammonium phosphate than those obtained from other plots.

TABLE I.

Yield of berseem, cowpeas and guar green fodder and wheat grain in maunds per acre.

Treatment per acre	Berseem Av. of 3 years (1941-43)	Cowpeas Av. of 3 years (1941-43)	1943-44 Wheat After fallow	1943-44 Wheat After cowpeas	1944-45 Cowpeas	1944-45 Wheat After fallow	1944-45 Wheat After cowpeas	1945-46 Cowpeas	1945-46 Wheat After fallow	1945-46 Wheat After cowpeas	1946-47 Guar	1946-47 Wheat After fallow	1946-47 Wheat After Guar
A. No manure (Control)	161	106	24·0	14·9	120	25·5	14·7	190	23·9	14·2	152	16·9	7·5
	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
B. F. Y. M. 80 lb. N (56 lb. P_2O_5 & 120 lb. K_2o)	321	136	27·0	20·9	154	32·6	18·1	211	37·4	19·4	170	19·6	7·8
	(201)	(128)	(113)	(140)	(128)	(128)	(111)	(156)	(137)	(137)	(112)	(116)	(104)
C. Superphosphate 132 lbs. P_2o_5.	336	120	30·8	24·2	149	35·1	27·3	209	29·7	21·9	175	21·6	11·5
	(209)	(113)	(128)	(162)	(124)	(138)	(186)	(110)	(124)	(154)	(115)	(128)	(153)
D. Superphosphate 198 lb.	378	125	29·9	26·2	148	35·2	32·6	181	30·8	27·3	191	21·7	12·6
	(235)	(118)	(125)	(176)	(123)	(138)	(222)	(95)	(129)	(192)	(126)	(128)	(168)
E. Superphosphate 264 lb.	369	132	29·7	25·5	160	37·9	36·1	179	31·7	27·9	176	20·6	15·0
	(229)	(125)	(124)	(171)	(138)	(149)	(246)	(94)	(133)	(196)	(116)	(122)	(200)
F. F. Y. M. 80 lb. N super 132 lb. P_2 o_5 or 80 lb. N, 188 lb. P and 120 lb. K_2°	414	138	25·5	26·4	164	38·5	32·9	216	35·0	24·9	206	24·3	17·7
	(257)	(130)	(106)	(177)	(137)	(151)	(224)	(114)	(146)	(175)	(136)	(144)	(236)
G. Complete artificials on the basis of 'B'.	366	142	31·3	23·9	151	33·7	27·1	214	33·6	20·6	189	21·8	10·4
	(227)	(134)	(130)	(160)	(126)	(132)	(184)	(113)	(141)	(145)	(124)	(129)	(139)

Figures in parentheses denote percentage on control.

ROTATION

Berseem	1940-41	Cowpeas	2/3 } 1943	Cowpeas	1/3 } 1945
Cowpeas	1941	Fallow	1/3 } 1943	Fallow	2/3 } 1945
Berseem	1941-42	Wheat	1943-44	Wheat	1945-46
Cowpeas	1942	Cowpeas	1/3 } 1944	Guar	1/3 } 1946
Berseem	1942-43	Fallow	2/3 } 1944	Fallow	2/3 } 1946
		Wheat	1944-45	Wheat	1946-47

TABLE II.

Chemical composition of berseem and cowpeas hay, wheat grain and wheat straw*.

Treatment per acre	% on dry material basis and total in lb. per acre						% on raw material basis and total in lb. per acre.			
	Berseem 1940-41			Cowpeas 1942			Wheat grain 1943-44		Wheat straw 1943-44	
	N	P_2O_5	CaO	N	P_2O_5	CaO	N	P_2O_5	N	P_2O_5
A. No manure (Control) ..	3·80 (169·8)	0·38 (16·7)	3·06 (146·1)	2·24 (62·1)	0·32 (8·9)	2·86 (79·3)	2·15 (31·8)	0·68 (10·1)	0·44 (13·7)	0·07 (2·2)
B. F. Y. M. 80 lb. N (56 lb. P_2O_5 & 120 lb. K_2O	3·95 (277·0)	0·48 (32·8)	2·95 (216·9)	2·10 (63·6)	0·42 (12·7)	2·65 (80·2)	..	..	..	..
C. Superphosphate 132 lb. P_2O_5	8·84 (297·9)	0·82 (80·9)	3·56 (285·3)	2·75 (85·4)	0·83 (25·8)	3·17 (102·7)	2·08 (45·2)	1·00 (21·7)	0·53 (24·8)	0·16 (7·5)
D. " " 198 "	3·74 (283·5)	0·95 (69·5)	3·69 (290·4)	2·71 (80·6)	0·90 (26·8)	3·49 (108·8)	2·04 (46·00)	098 (22·1)	0·51 (24·4)	0·16 (7·7)
E. " " 264 " ..	4·19 (336·6)	1·12 (85·9)	4·14 (352·9)	2·69 (76·5)	0·83 (23)·6	3·11 (97·0)	2·01 (44·5)	1·10 24·4)	0·51 (25·1)	1·04 (6·9)
F. F. Y. M. 80 lb. N + super 132 lb. P_2O_5 80 lb. N, 188 lb P_2O_5 and 120 lb. K_2O.	3·72 (300·7)	0·83 (65·6)	3·70 (313·7	2·32 (70·3)	0·76 (22·7)	2·87 (35·9)	2·16 (46·4)	1·15 (24·7)	0·69 (32·8)	0·22 (10·5)
G. Complete artificials on the basis of 'B'.	3·66 (301·6)	0·74 (60·1)	3·39 (297·7)	2·81 (88·0)	0·67 (21·0)	2·96 (92·7)	2·05 (44·5)	0·69 (15·0)	0·61 (27·3)	0·11 (4·[illegible])

Figures in parentheses denote total constituent in lb. per acre.

*These analyses were carried out in the Chemistry Division of the Institute.

TABLE III.

Yield of manured berseem green fodder and unmanured maize and Wheat grain.

Treatment per acre	Yield in maunds per acre				Combined yield of maize and wheat (3 crops)	Per cent on control
	Berseem 1944-45	Maize 1945	Wheat 1945-46	Maize 1946		
No manure (control)	139·7	24·1	22·7	19·4	57·2	100
Bonemeal 120 lb. P_2O_5	172·6	22·9	27·4	11·8	62·1	109
Am phosphate 120 lb. P_2O_5.	262·8	26·5	25·7	12·0	66·2	116
Superphosphate 120lb. P_2O_5.	144·1	21·1	22·3	9·9	53·3	93
Bonemeal an d am. phos each at 60 lb. P_2O_5.	191·7	23·1	26·7	15·6	65·4	114
Bonemeal and super each at 60 lb. P_2O_5.	161·9	23·4	28·1	12·3	63·8	112

Phosphate manuring of sannhemp for green manuring.

The results of the permanent manurial and rotation experiments carried out at Pusa, covering a period of 22 years between 1908-09 and 1929-30 in which green manuring with sannhemp in conjunction with superphosphate was included, are of considerable interest. The results show that the best yields were obtained when sannhemp used for green manuring was grown with superphosphate. Green manuring alone was ineffective. The yields of pigeonpea were affected by wilt which masked the effects due to treatments to some extent.

TABLE IV.

Permanent manurial and rotation experiments, Pusa. Yield of grain in maunds per acre (1908-09 to 1929-30).

Treatment per acre	Maize	Piegon-pea.	Oats
1. No manure (control)	6·6 (100)	8·8 (100)	5·5 (100)
2. F. Y. M. 20 lb. N	10·9 (165)	13·0 (148)	10·0 (182)
3. Rape cake 20 lb. N.	10·4 (158)	10·9 (124)	7·5 (136)
4. Am. sulphate 20 lb. N.	6·6 (100)	10·7 (122)	5·5 (100)
5. Super to supply P2o5 as in No. 2	10·3 (156)	10·1 (115)	10·0 (182)
6. Am. Sulp. Super and pot. sulp to supply N, P2o5 and and K20 as in No. 2.	11·9 (180)	9·4 (107)	10·5 (190)
7. Green manure with sannhemp.	11·0 (167)	8·1 (92)	8·3 (151)
8. As in No. 7 and sup to supply P2o5 as in No. 2 ..	15·9 (241)	8·6 98)	19·1 (347)

Rao (8) working in Mysore on the effect of green manuring on the yield of paddy stated that the yields from plots green manured with sannhemp and cowpeas treated with phosphate gave 2,520 and 2,080 lb. of paddy per acre respectively, whereas, the same without phosphate gave only 1,840 and 2,120 lb. per acre. Both these results were significantly higher than that from 'no green manure' plots which averaged 1,360 lb. per acre.

The results of these experiments indicate the role of phosphate in conjunction with legumes grown for fodder and green manuring in building up the soil fertility, resulting in increased yields of cereal crops which follow.

(Figures in parentheses in Table IV denote percentage on control).

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SUBJECT I(b).

REVIEW OF THE WORK DONE ON THE MAINTENANCE OF SOIL FERTILITY IN INDIA WITH SUGGESTIONS FOR FUTURE LINES OF WORK WITH PARTICULAR REFERENCE TO THE EFFECT OF THE SOIL FERTILITY ON THE QUALITY OF CROP PRODUCTION.

Apart from breeding of high yielding varieties, crop production depends to a large extent on soil fertility and its maintenance. Quite often, it has been the experience of workers to find certain crops and certain varieties, thriving well in certain localities. This is evidently due to the most favourable environmental factors under which may be considered mainly : (1) the soil, (2) the source of water-supply, and (3) the climatic factors. The need arises, therefore, for an intensive study of the relationship of these three factors and to see if certain localized influences are responsible for increased yield of crop and if

these could be under controlled conditions, introduced in other localities. The subject will fall under three lines of investigations :—

(a) soil survey,

(b) study of irrigation waters, and

(c) meteorological data.

For the present, a scheme to study the first two factors may be undertaken.

Soil survey.—Previous work by the Madras Agricultural Department has mostly been confined to the deltaic areas. The work originally started with the survey of the Tanjore district, which showed that the delta soils were highly deficient in Nitrogen and available Phosphoric acid. Later, soil surveys of Godavari, Kistna and Malabar districts and of the Periyar project area were undertaken and similar deficiencies were found as the result of chemical analysis. All these surveys related to what may be called predominantly rice-growing areas and emphasis was towards the supply of the necessary Nitrogen and P_2O_5 on an acre basis, for ensuring a high yield of paddy.

A second aspect of soil survey was taken up in connexion with several proposed irrigation projects :—The Toledar project in South Arcot, the Gundlakamma project of Guntur, the Lower Bhawani project in Coimbatore and the Tungabhadra project in Ceded Districts. The object of these surveys was primarily to study the irrigability of the soils of these areas with the particular irrigation source, although incidentally a large number of samples of soil were available for studies on soil fertility.

Recently, after the cyclone in 1945 along the North-East Coast, a soil survey of the coastal area inundated by sea waters was undertaken to assess the damage to the physio-chemical properties of the soil subject to such flooring. In the Ceded Districts, again, a soil survey of the tract was done to study the possibilities of the development of fruit trees culture. Some years ago, at the instance of the District Agricultural Officer a survey of the tobacco area in Guntur and Lanka was also done to correlate the quality of the Virginia tobacco with the nature of the soil.

It will be seen from the above outline, that while a number of soil surveys have been done in the past by the Madras Agricultural Department, they have been carried out with a specific object and not with a comprehensive idea of getting information on soil fertility. in different areas, dry, wet and garden land of our Presidency. To-day, with a new orientation possible in the reconstruction of the agriculture of our country on a scientific basis, the first desideratum therefore is, sufficient data on our soils, and this can be obtained only by a thorough and systematic soil survey of the whole Presidency. It should be possible in the course of few years, by organized planning and hard field and laboratory work, to have a map of the country, showing the localities of high, low and poor fertility , and the crops which could be grown there was minimum effort and maximum efficiency. In other words, we should aim at having definite zones for

different crops where they will flourish best under local conditions and it is on this basis even, that further improvement by way of selection and breeding strains should develop.

Study of Irrigation Waters.—Along with the soil survey, a survey of all our irrigation sources, well, pond, channel and river in different seasons should also be undertaken. The importance of water for promoting crop growth cannot be over-emphasized. But the effect of the quality of the irrigation water on the quantity and quality of crops has not been studied in great detail or in a scientific manner. There are very many popular nations, but they have not been tested; for example, it has been my experience during the Lower Bhawani project and the Tungabhadra project surveys with which I was intimately connected, to hear ryots informing that sweet water is no good for brinjals, tobacco, chillies and other solanaceous crops which require saline water for thriving well. Again there is a popular belief that all well waters in black soil area are saline, those in red soil areas are sweet, although there are exceptions. It has recently been my experience to find in many of the wells and water sources near Bapatla, large quantities of magnesium chloride which is wholly absent in inland wells. It is reported in literature, that near the sea coast, tidal influence under the soil layer may make itself felt at even 10 miles distance. It is also seen that wells in a particular belt are saline, while hardly a few yards away the wells contain sweet water. These experiences must be investigated with methodical analysis before we can explain.

Alkali Reclamation.—Along with soil surveys and study of irrigation water, an attempt must also be made to reclaim alkali lands wherever they exist and bring them under cultivation. Information on the existence, extent and nature of alkali lands near each village is lacking—once again a survey is indicated.

I would therefore suggest that the meeting of the soils and crops wing bestow their attention to these problems and bring into operation a scheme for such surveys—with a time-limit of, say, 5 years—by which time we will be in full possession of facts and be in a position to suggest measures for improving soil fertility.

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7th January 1948.

SUBJECT 1(b).

REVIEW OF THE WORK DONE ON THE MAINTENANCE OF SOIL FERTILITY IN MADRAS PROVINCE.

The soils of the Province with a very few exceptions are extremely poor in essential plant food elements especially Nitrogen and phosphoric acid and in organic matter. The yield of crops in consequence has been

going down year after year due to intensive cultivation without adequate attention being paid for the maintenance of soil fertility by way of enriching soil organic matter and addition of suitable manures to meet even the minimum requirements of crop growth. The Madras Department of Agriculture, realising this defect, have been carrying on an intensive scale a number of manurial experiments to recoup the soil fertility and increase incidentally the yields of the various economic crops of the Province for over three decades and more in the different Agricultural Research Stations representing typical soils and environmental conditions. The review of the work done so far to improve crop production and soil fertility indicates the following salient points :—

(1) The importance of bulky organic manures such as green manure, Farm-yard manure and|or compost for maintenance of normal fertility of soils—both wet and garden lands.

(2) The necessity for addition of artificials like ammonium Sulphate. super, etc., and oil cakes, to provide easily available Nitrogen and phosphorus to crops, in sufficient quantities for increased crop yields of good quality in conjunction with bulky organics.

Paddy soils—Green manuring for paddy which forms a major food crop of the Province, has been found universally the best in all the tracts and its effect is felt better in combination with easily available phosphates. In Anakapalle (Vizagapatam district), increased yields were obtained up to 20 per cent. by applying green manure at 3,000 lb. per acre. At Samalkota in the same district. "green leaf 2,000 lb. plus Bone meal 224 lb" gave very good yields. With regard to Maruteru representing the deltaic area of the Kistna and Godavari "Green manure 4,000 lb. plus super 112 lb. plus Ammonium sulphate 80 lb. or its equivalent in oil cakes" gave 40 per cent. significant increase over green manure alone. Passing to Palur in the South of Madras (South Arcot district), the response of paddy to green manuring even at 9,000 lb. per acre is next to nothing, showing thereby, the inherent fertility of this area which is maintained probably by the periodical deposit of silt from the irrigation water of the Goddilam river. At Aduthurai, in Tanjore Delta, Nitrogen by itself gave good yields when applied as cake or ammonium sulphate. The combined effect of the two, both the nitrogenous and phosphatic manures, was more potent. The phosphates by themselves did not fare well in any of these major paddy growing areas. Again, a phenomenal increase of 60 per cent. over control has been recorded at Pattambi—representing Malabar soils of laterite origin. When ammonium sulphate (75 lb. to supply 15 lb. Nitrogen is applied with green leaf (4,500 lb.) in conjunction with oil cakes such as neem, castor. or groundnut much better response has been observed in the same station for ammonium sulphate when the ratio of organic to inorganic Nitrogen is 2 : 1, the total nitrogen being 45 lb. Nitrogen. Summing up, it can be asserted with confidence that fertility of paddy soils in the Province can be kept at suitable levels to produce an average acre yield of 2,000 to 2,500 lb. by incorporation of 5,000 lb. green manure, either alone or preferably in combination with the following :—ammonium sulphate or oil cakes in any form to supply 15 lb. Nitrogen.

In addition to this practice, necessary for maintenance of inherent fertility of these soils, phosphates such as super (1½ cwt.) or fish guano (400 lb.) ammo-phos (30 lb. P_2O_5.) may have to be added if possible every year or at least once in two or three years for increased crop production and to assure the quality of the grains

Experience on the manuring of paddy has also revealed the absence of any residual effect of nitrogenous manures of any type in particular on the succeeding crop. This emphasises the need for renewed application of these manures every time the crop is raised.

Garden and dry land areas.—The manurial trials with dry land crops such as jonna, cotton, show further that apart from the necessity of applying farm-yard manure or compost (5 tons per acre) to maintain the organic matter and biological activity in the soil, incorporation of ammonium sulphate (1 cwt.) per acre has proved extremely beneficial in increasing the yields both directly and residually. The effects of farm-yard manure in appreciable doses, 5 tons per acre has been felt even up to three years in the garden and the dry land areas.

The commercial crops like sugarcane, yield well in properly managed and heavily manured soils with good drainage. Application of cake and ammonium sulphate each providing the same quantity of Nitrogen the total being 100 lb. Nitrogen per acre over a basal application of 10 tons farm-yard manure, is absolutely necessary to keep up the fertility of the soil consistent with normal yields.

Treatment of alkaline soils with gypsum and green manure in Pattukottai (Mettur Project area) and in Trichy district has contributed to their reclamation. Subsequent crop yields in the reclaimed lands revealed an improvement in their fertility.

Soil fertility on the quality of crop production.—The only noteworthy contribution on the subject is by R. McCarrison et. al (Memoirs of the Department of Agriculture in India, IX No. 4; 1927). These authors studied the nutritive value of the millets *Elesuine Coracana* and *Panicum milaceum* and of wheat obtained from the permanent manurial plots of the Government Agricultural Chemist, Coimbatore, receiving chemical and organic fertilisers. The differences were traced as far as feeding tests. It has been reported by these authors that in contrast to the yield without fertilising, chemical fertilising gave a yield increase of 32.8 per cent. and organic fertilising an increase of 100.7 per cent. in the case of *Panicum milaceum*. The reproductive capacity of the seed from the organic manure plots (Farm-yard manure) was tested and found superior to these from the plots treated with inorganics. In regard to feeding value of the grains from the two differently manured plots, the following observation made by them deserves consideration :—" Even with manifold changes in the condition of the experiment a better result was evident in the case of the seed raised with organic fertilisers than with seed raised with chemical fertilisers. In the case of the wheat, the seed raised with chemical fertilisers reacted less favourably than the seed raised without fertilisers ". This view on the superior effect of organic fertilising on the cereals has received the support of other scientists also, the prominent among them being Sir Albert Howard formerly Director of the Indore Institute of Plant

Breeding—(Farming and gardening for Health or disease—Faber and Faber London, 1945)—Professor Boas of Munich (Praktische Blatter-fur—Pflanzenban IX P. 173 : 1932). Ehrenfried Pfeiffer (Soil Fertility, Renewal and Preservation—Faber and Faber Limited. London, 1945—pages 148-163). The experiments of these workers stress in short. the higher biological value of grains from plants fertilised with stable manure, than that of corresponding seeds from the minerally fertilised plants. The investigation by the Rothamsted workers reveal on the other hand, no significant difference in the biological value of wheat grown on plots differently but consistantly manured for nearly a century and this has been confirmed for several other crops in shorter term. The few data available suggest, that the effect of nutrient supply on vitamin A production is small though Nitrogen may have a stimulating effect. The whole problem requires elaborate and intensive study of differently manured crops under local conditions before any conclusions are drawn.

Suggestions for future line of work.—A. Maintenance of soil fertility.—It is apprehended by eminent agriculturists, scientists and administrators of this country and elsewhere, that the increased acreage of arable land and the more intensive system of cropping will exhaust the fertility of the soil and leave a legacy of poverty. There is a good deal of confused thinking on this point. A good many consider fertility and humus synonymous and so, farm-yard manure the chief source of humus on most farms, is hailed to the skies and attributed with magical properties. The use of artificial fertilisers, is decreased on the score that they rob the land of its fertility and act simply as forcing agents. By long experience, methods have been evolved in countries like China, for balancing the constructive and destructive soil processes, the systems adopted being that of a sound rotation, involving mixed cropping wherever found suitable and proper conservation of natural organic manures. In a proper system of rotation, restorative and exhaustive crops alternate, the plant foods are utilised equally and periodic applications of dung or green manure maintain the physical condition of the soil. Recent work in most countries has shown how modern resources of plant breeding machinery and fertilisers can be harnessed to establish productive leys, a most potent source of fertility. It is evident that we can as well establish a balanced and safe agriculture at a much higher level of production than was possible some years ago.

A fertile soil contains N. P, K and CaO and minute traces of vital eliments like boron, manganese, etc. It should be well drained and of the right texture. A judicious combination of plant food in both organic and inorganic forms is further necessary to obtain the maximum crop of which the soil is capable of the maintenance of fertility as conceived by many is not therefore simply a question of adding farm-yard manure, compost, or green manure. It involves all the mechanical processes necessary for tilth forming. It means making good the losses of both organic matter resulting from cultivation and of plant food following the harvest of a crop. It also means the protection of surface soil from erosion or by floods. The Chinese method

of maintaining soil fertility is worth emulating. All work in that country is manual labour. Mineral fertilising is still unknown to the Chinese farmer. The intensive cultivation in China rests on humus and compost economy carried on with almost religious zeal. Scientists who have visited the cultivated areas of the country and studied them from the back ground of their technical knowledge say that a crop failure in such lands is a rare occurrence unless it be an act of Providence. Humus conservation and manual labour are the main factors responsible for the maintenance of soil fertility in this ancient land. Moreover, the productive capacity of each type of soil should be assessed in relation to its enviroñment and make up. This factor is not directly proportional to the amount of fertiliser applied. A cultivated field should be judged as a biological entity or organism and as such is subject to the laws governing the organic. It has its critical point of inner effective power which is the resultant of the varied factors, namely, the mineral constituent the physical structure, the presence of organic substances and their conditions (humus) acidity, etc., microbiological population, climate, methods of cultivation, varieties of plant growth, activity of plant roots, ground cover and cover crops versus erosion, possibility of the occurrence of wheathering processes, proximity or otherwise to wood-land, etc. Of the various agencies responsible for maintenance of soil fertility, the legumes are equally very important, as only by their use, can a significant proportion of the natural reserves be brought into use for the fertilising of the soil, *i.e.*, seven to sixty fold more powerful than a cereal. It is worth while to recall in this connexion the method that is being adopted by the T.V.A. for enriching soil fertility. Phosphates are applied and legume grown year after year and ploughed in to achieve this object. The legumes should therefore form a part of a healthy crop rotation as a curative factor. Since the productive capacity of a soil depends on the variety of factors connected with the life processes of both plant and animal, precautions should be taken to preserve its biodynamic condition at a high level. The steps recommended by P. Feffer (loc cit.) for the purpose are :—

(1) Consideration of what is desired and what can be done.

(2) Proper care of the manure.

(3) Improving the quality of the manure.

(4) Setting up healthy crop-rotation and improving the method.

(5) Improving the feeding with home grown feed.

(6) Improving the herd as a whole.

In the words of the same author "the natural fertility and production capacity are the functions of (1) soil, (2) manuring, (3) humus tillage, (4) rotations, (5) climate, (6) weather conditions, (7) quality of seed, (8) weed growth and a number of environmental factors". All these should be borne in mind in management of cultivable soils for maximum crop production. Next question to be considered is the economic use of fertilisers avoiding wastage and resorting to right method of their application at the proper time. Recent work indicates that small application of fertilisers in close proximity to the seed may be as effective as the mormal heavier doses applied broadcast, splitting

the doses of manures and their application at different stages of plant growth has also in cases like sugarcane, been found efficient in increasing the yields appreciably. Supplies of farm-yard manure, oil cakes and other manures being limited, the substitution wherever possible of green manuring and other alternatives such as composts have to be considered. Much more attention should be paid to the conservation and storage of farm-yard manure, which constitute an important national supply of vital plant food. Above all, maximum cropping which is closely allied to maintenance of soil fertility, demands ingenuity on the part of the farmer, combined with a thorough understanding of his soil and its capabilities. Careful planning, generous manuring, skilful cultivation and wise selection of variety are the surest means of solving our cropping problems.

B. Quality of the grain as affected by manuring.—According to an influential school of thought represented by eminent scientists like Howard, Br. Pfeiffer (loc. cit.) and others, there is a definite correlation between the health of animals and human beings and the nature of the food consumed by them. As stated already the grains from plots receiving farm-yard manure have been reported to by a number of workers including Mc. Carrison et al. and his collaborators in this Province (loc. cit.) are of better nutritive value being rich in vitamins than those from the mineral manure plots. This point is still being disputed, further work has to be done with a variety of crops grown under different environmental conditions to test the observation. Opinion is also current that high yielding strains are poor in quality especially in regard to protein content and economically, they are not also suitable for our already impoverished soils as they remove more of workers including Mc. Carrison et al. and his collaborators in this pointed out by Berg (Lantmannen, 1940 : 24 : 315) and others that the protein production could not be increased by breeding of new varieties since it has been found that there is an inverse relationship between protein content and the grain yield. The only possible course therefore of raising the normally low protein content of high yielding crops or varieties and thus increase the protein production per unit area lies evidently, according to these authors in late top dressing of crops with easily available nitrogenous fertilizer such as ammonium sulphate. Observations in Germany and Scandinavia have also encouraged the belief that this process opens up new possibilities for increasing the protein contents of crops. This important finding has to be tested with some of the local food crops, primarily rice in this Province.

In fine, from the foregoing note, setting forth the results of the manurial and other experiments relating to the maintenance of soil fertility and its bearing on human nutrition, with suggestions for future line of work, it is clear, that in designing our pattern of agriculture we should base our faith for increased production, upkeep of soil fertility, primarily on (1) judicious use of organics and inorganics suitable to the locality and crops, (2) mantainance of bio-dynamic status of the soils in a healthy condition particularly by encouraging the growth of beneficial micro-organism and resorting to sound rotation

of crops including legumes, and (3) skilful management of soil by adopting efficient methods of cultural operations to prevent loss of surface soil due to erosion and preserve soil tilth in proper condition. Apart from these practices the effect of different systems of fertilising on the quality of crops should be studied *de novo* under varied conditions of farming and environment to clarify the existing views on the subject which run counter to so many fondly held dogmas in the spheres of agriculture and nutrition.

AGRICULTURAL DEPARTMENT,
MADRAS,
9th December 1947.

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Subject No. 1(b).

A REVIEW OF SOIL WORK DONE IN THE UNITED PROVINCES WITH PARTICULAR REFERENCE TO CROP PRODUCTION.

By

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There are in the United Provinces three district tracts differing from one another in their geological formation and other characteristics. These tracts are :—

(a) The Hill tract in the north.

(b) The Bundelkhand tract in the south.

(c) The Ganga alluvium in the centre.

Work on the soils of these three tracts has been in progress chiefly on pedological principles and the main object has been to study the condition or set of conditions that influence the yield and quality of crops growing in these regions. A number of manurial trials on the soil types characterised in some of the regions of the tract was also laid to study the manurial requirements.

A brief summary of the more important results obtained so far from these studies is given below tract-wise :—

(a) *Hill tract in the North.*—The investigations were started since 1934 at the Soil Chemistry Section of the Hill Fruit Research Station at Chaubattia, Ranikhet under a scheme partly financed by the Indian Council of Agricultural Research.

(i) *Rock formations and soil characteristics.*—There are principally two rock formations in Kumaon hills which are important from the stand point of soil formation. They are biotite schists and phyllites. Soil formed from both these differ fundamentally. The SiO_2/R_2O_3 ratio of colloidal clay minerals from soils derived from biotite schists is 2.62 ± 0.10 and of soils developed on phyllites is 2.15 ± 0.062. On

an average, is has been found that biotite soils are poorer in phosphates and richer in potash than the phyllitic soils and consequently manuring with phosphates has always given good results in biotite zones.

It has been found that the soils irrespective of the nature of rock formation can be divided into three important genetic soil types *viz.*, (i) brown forest soils, (ii) podsolic soils and (iii) wiesenbodens or meadow soils. (Mukherji and Das, 1940). Under terraced conditions brown forest soils are stable ; whereas, podsolic soils tend to assume characteristics of brown forest soils. (Mukherji and Das, 1941). The data indicate superior inherent fertility of brown forest soils as judged by the distribution of organic matter, lime, total and available phosphorus and potash and exchangeable calcium. Due to high acidity and deeper eluviation of nutrients in podsolic soils the plants cannot flourish so well on these soils as a brown forest soils. Wiesenboden soils are found under water-loged conditions. The nature and characteristics of soil hypes studied on different commercial orchards are found to be similar to those found at Chaubattia. (Mukherji and Das) (1942).

(ii) *Soil conditions and differential behaviour of fruit trees.*—From the detailed soil survey data it is clear that soil condition influences productivity, heavy loam brown forest soils and heavy humus-porsolic soils are best suited for growing apples. Iron podsols and hard clay soils, Sandy stony soils and sandy loam brown forest soils are considered to be very inferior for the purpose. Similarly for peach, apricot, plum and cherry sandy-loam soils are considered to be better. Further detailed study of yield data has shown that vigour of fruit trees is largely dependent upon the moisture status of soils, all well formed trees being generally found in areas where the soil has a good moisture holding capacity. Considerable correlation has been found between the soil condition and the incidence of diseases and insect pests of fruit trees. For instance, the incidence of apple root borer is more serious on soils which are sandy and dry. (Annual report Hill Fruit Research Station, Chaubattia 1938-39 pages 49-51). Similar observations have been made in regard to pink disease, and root and coller-root of apple plants. (Annual Report 1938-39, 1939-40 and 1940-41).

(iii) *Soil Survey of Commercial Orchards.*—Soil survey work was also started on some of the important commercial orchards in the hills with a view to give the owners advice regarding the prevailing soil conditions. These orchards are (a) Doonagri Estate, (b) Pine View Orchard, Bhowali, (c) Somerford Orchard, Ramgarh, (d) Allen Orchard, Ramgarh (e) two orchards at Binsar, (f) some orchards at Ranikhet, (g) orchards at Kansani, (h) orchards at Gorakhal and Sham Khet and (i) Niaz Estate, Majkhali. The nature and characteristics of soil types studied on the above orchards were almost similar to those found at Chaubattia. In general, the soils are acidic and need liming together with some form of phosphatic manures. Proper moisture consideration was another factor needed for successful fruit cultivation.

(b) *Bundelkhand tract in South.*—The part of the United Provinces lying south-west of the river Yamuna is known as Bundelkhand. The tract is non-alluvial in nature and the soils have been formed by the

disintegration of the Central Indian hills. Geologically the whole of the Bundelkhand is occupied by gneiss and some of the beds are highly ferruginous. Sand-stones, lime-stones and slates are also found but these usually rest on the under-lying beds of gneiss. The climate is exceedingly dry. Soil work in this region was started in 1941 and continued till 1946.

(i) *Soil formation and soil characteristics.*—Three genetic soil types have been recognised in this tract which have been termed as Bundelkhand type I, Bundelkhand type II and Bundelkhand type III. Type I is a reddish brown coarse-grained soil very shallow in depth. This is under-laid with the parent undecomposed material. The soil is very poor in colloids and in plant nutrients and is of an open texture allowing free drainage of water. No good cultivation is possible on this type of soil. This type is found on high-lying areas. Type II is found on milder slopes or on comparatively level plains. This has got a brown colour and varies considerably in texture. It is possible to find a sandy, loamy or clayey sub-type. The soil has a greater depth and is usually underlaid with zone of calcium carbonate accumulation in the form of *kankar* layer. This type is suited better to cultivation provided manuring and irrigation facilities are available. Type III is the clayey type found usually in low-lying areas and in plains. This is also calcareous and dark brown to jet black in colour. These soils are by far the most fertile soils of the locality. This type has formed as a result of restricted drainage. (Mukherji and Agarwal, 1943).

Yet another type of soil, not fundamentally different from type III, occurs in the extensive plain areas of the region south-west of Kanpur mostly in the district of Jalaun. This type is reputed to constitute the most fertile soil of the locality. Morphological examination did not reveal any distinct variation from the type III already described excepting that the structure of the profile of plain soils was more crumby. The soils were found to be poorer in sodium content as compared to type III soils. The soils were on analysis found to be poor in coarse sand and contain from 40 to 45 per cent. clay in the top layers. They are fairly well supplied with nitrogen and potash but are average in phosphorus. The pH is alkaline to the presence of lime. The exchange capacity was found to be fairly high. The clay fractions showed richness in basses and the iron present was mostly in an uncombined state. The predominating clay minerals were identified as montmorillonites. (Agarwal and Mukherji, 1948).

The Bundelkhand soils have been classified as 'tropical tsernozems' and this classification has been further corroborated by a study of the isolated clay fractions. The value for the silica-sesquioxide ratio varies from 2.604 to 2.995 and that of silica-alumina ratio from 2.661 to 3.870. It has been reported that in the immature type I some evidence has been found of laterisation resulting in iron accumulation at the surface. (Agarwal and Mukherji, 1947).

(ii) *Soil conditions and crop behaviour.*—The three genetic soil types have distinct crop adaptibilities. Type I is suited for very inferior type of crops like *til* in the *kharif* and gram in the *rabi*. In

type II soils *jowar* is cultivated in the *kharif* and gram in the *rabi*. The cultivation of wheat or linseed is possible only in type III soils.

Methods of dry farming as suited to the three soil types including preparatory tillage operations, *bunding* or mulching, etc., are in the coarse of investigation. It has been tentatively found that shallow ploughing coupled with *bunding* the fields give increased yields of crops in type I and type II soils.

(c) *Gangetic alluvium in the Centre.*—The soils in this tract have been formed as a result of the deposits laid down by the river Ganga and its tributaries. The tract is a vast region occupying the whole of the central United Provinces. The differences in soil characteristics are mainly climatic and on the basis of such considerations the Ganga alluvium of the United Provinces has been divided into a number of distinct soil-climatic regions. Soil work has been done during 1940-44 only for the following areas :—

(1) The Unnao and Hardoi districts.

(2) The Gorakhpur and Deoria districts.

(1) *Unnao and Hardoi Districts.*—The soils of Unnao district show characteristic of sodium soils. The types so far met with are (a) immature salty-alkali soils, (b) salty-alkali and (c) degraded salty-alkali soils. The first type is usually found in *tarai* (low-lying) areas and is generally light loam in texture. The colour is more or less ash-grey. These do not constitute very fertile soils since cultivation is usually precarious due to periodic inundations. Salty-alkali soils cover by far the major portion of the tract. The texture is generally sandy loam at the surface succeeded by layer of clay in the bottom. The soils are grey in colour and of average fertility. These occur with or without a *kankar* layer. Degraded salty-alkali soils are the leached soils showing reddish yellow colour and sodium cation is practically found absent from the top layers. They are of an open texture and contain exchangeable sodium in large amounts in the sub-soils only. A regional map of the district showing the distribution of the soil types was also prepared (Mukherji, Agarwal and Mukerji, 1946).

In the district of Hardoi, which lies slightly towards the north, soils showing characteristics of 'brown chestnut soils' have been found.

Results obtained for the Sandila Tehsil in particular and for the Hardoi district in general, have furnished some very interesting developmental characteristics of the soils of the locality. It has been found that the soils bordering the river Gomti towards the north-eastern part of the district are highly sandy in texture, the chief chemical feature being the high sodium content both in the soil solution and the exchange complex. The soils are devoid of calcium as well as plant nutrients and in consequence support only poor types of crops. The soils of this tract, however, slightly improve in texture towards the south-west. Bordering this zone there is a broad strip of low-lying land in the central part of the tehsil where the soil has become alkaline and due to imperfect drainage the landscape is found disfigured by large stretches of *usar*. Beyond this area the soil again becomes medium loam. On the western part of the tehsil the belt of land on either

side of the river *Sai* is of good fertility and the soils of that area are still rich in calcium having a good drainage since sodium has not so far produced a harmful effect. A soil map of Sandila Tehsil has also been prepared. (Mukerji and Agarwal, 1947).

(b) *Sugarcane soils of the Gorakhpur and Deoria districts.*—Gorakhpur and Deoria happen to be two of the main sugarcane growing districts of the province and the work has been concentrated in these districts since 1942 with a view to understand some of the fundamental changes that might be undergoing in the soil as a result of intensive cane cultivation. The main factors under study have been the chief manurial requirement of the crop under different cultural and irrigational practices, the selective adaptability of the improved varieties to soil types, the suitability or otherwise and the dosages of artificial fertilisers etc. The final aim is to find what set of treatments produce maximum yield of cane in relation to long-term soil usage.

(i) *Genetic soil types and their characteristics.*—It has been shown as a result of an intensive soil survey that the soils of Gorakhpur and Deoria districts can be divided into the following main three types :—

(a) Calcium soil with a large reserve of lime (type I).

(b) Leached calcium soil with a layer of calcium carbonate in nodular from (*Kankar*) at the bottom (type II).

(c) Degraded calcium soils in which the calcium in the exchange complex has been partially replaced by hydrogen (type III)

Detailed descriptions of these soil types which differ from one another in marked degrees of contrast have been given in the annual reports of the sugarcane research work in the United Provinces. A regional map showing the distribution of the soil types in the districts has also been prepared along with some detailed zonal maps in which a field-to-field soil survey was undertaken.

(ii) *Quality and yield of cane as affected by soil types.*—In order to study the differences in the performances of different popular cane varieties as affected by the three soil types enumerated above a number of crop-cutting experiments were conducted on cultivators' fields. The juice was also analysed for quality. Briefly the data indicate that Co.356 suits type I soils, Co.370 suits all the three types and Co.421 type III best. Amongst the early varieties the indications are that Co.395 suits type I and type III and Co.393 type II soils Co.313 has given a poor performance throughout so far as the cane yields are concerned but a good sucrose content in cane was obtained, although not as good purity as compared to the other early varieties.

(iii) *Manurial requirement of cane as affected by soil types.*—Three manurial trials with all combinations of three levels of nitrogen (N_0, N_1 and N_2) and three levels of phosphoric acid (P_0, P_1 and P_2) were conducted one on each of these soil types. They were conducted for four cane seasons on cultivators' fields in close co-operation with the staff of the Sugar Industry.

It is interesting to note that a considerable increase in the yield of sugarcane can be obtained by liberal nitrogenous manuring in type

I. soils and phosphatic manuring does not appear to be necessary. In type II soils on the other hand, besides manuring with nitrogen a supplement of about 40 lbs., phosphoric acid per acre has been found to be beneficial for crop production. In type III soils phosphoric acid application is unnecessary and nitrogen application over 60 lbs., per acre did not produce significantly higher yields, but an application of lime appears to be beneficial in addition to nitrogen. (Mukherji, Agarwal and Mukherji, 1944).

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SUBJECT 1(b).

Review of the work done on the maintenance of soil fertility in India with suggestions for future lines of work with particular reference to the effect of soil fertility on the quality of crop production.

(Note by Dr. Dalip Singh).

There is no denying the fact that the average yields of principle crops in this country are much lower than those obtained in foreign countries, the reason is that no serious efforts have been made either to improve soil fertility or even maintain it at a proper level. This has resulted in the soils having stabilised to a low standard of fertility. Soil fertility is usually judged by crop yields, as between two soils the one giving a better yield is regarded as more fertile. But there are a number of factors which constantly operate is the soil, and from this point of view, the soil may be regarded as a highly complex factory in which various processes going on all the time lead

to the availability of nutrients required by the growing plant. The factors which contribute towards building up soil fertility are given below :—

(1) Texture of the soil.
(2) Crumb formation.
(3) Cultural Practices.
(4) Crop rotations.
(5) Availability of plant nutrients.
(6) Microflora.

(1) *Texture of the soil.*—The texture of the soil is an important factor bearing on soil fertility. Broadly speaking the soil consists of clay, silt and sand fractions plus a certain amount of organic matter. For the soil to be fertile there should be such a harmonious combination of these components. The soil should neither be too loose as to be lacking in water-holding capacity nor too compact as not to permit of the easy penetration of roots into the sub-soil. A special study of this problem has been made by E. J. Russel and his findings have been pubiished in the form of a monograph, but I doubt very much if any elaborate work on these lines has been attempted in this country. The texture not only relates to surface soil but also to sub-soil. In some of the recent studies (data unpublished) it was observed that the gram wilt disease in certain semi-arid parts of the Province was due to high compaction of 6 to 18 inches layer of the soil. It is necessary to undertake these studies on a more extensive scale.

(2) *Crumb formation.*—The formation of proper sized crumbs is an important factor contributing to soil fertility. An intensive study on this aspect of the problem has been carried out by Russian Scientists. Recent studies carried out in this Province led to the fact that particles below 2. m.m. in size contribute greatly to soil fertility. Therefore, in all methods of cultivation it should be the aim of the cultivators to produce particles of the requisite size as a result of various cultivation practices. There is a great scope for pursuing these studies more intensively.

(3) *Cultural practice.*—The aim of all cultural practices is to produce a proper seed bed, conserve the necessary amount of moisture, and render necessary plant food materials available for the growing plant. The number of cultivations to be given to a particular type of the soil is still a debatable question. On the one hand, there is the slogan "dab kay bah tey raj kay khah" the more you plough the better crops you get. On the other hand, there is the booklet of Faulkner " on the ploughman's folly ".

Which deprecates the idea of excessive ploughings and recommends that ploughing is essential only for the preparation of a suitable seed bed and for the eradication of weeds. Recent experiments carried out in the Punjab under irrigated conditions of Lyallpur and Montgomery (data unpublished) have shown that out of all the crop growth factors such as total nitrogen, available nitrogen, moisture, organic matter, plant nutrients, crumb formation and weed population, it was only available nitrogen and weed population, that were affected as a result of

varying number of cultivations. The increase in fertility in the case of Lyallpur soil, where the soil was initially at a lower status of fertility was reflected in increasing crop yield as a result of increasing number of cultivations, but in case of Montgomery soil which was initially at a higher level of fertility no such effect was visible by increased number of cultivations. Detailed experiments in order to throw light on this important factor were planned in the united Punjab but owing to the partition of the Province the work could not be pursued any further.

(4) *Crop rotation.*—The inclusion of a suitable crop rotation in any system of crop planning is a very important factor. Each tract has from time immemorial followed certain crop rotations which appear to be suitable for those localities. The Department of Agriculture as a result of experimentation on different farms have evolved suitable rotations for particular localities. But the effect of different rotations on the soil fertility has not been investigated in detail so far. A beginning was made at Lyallpur to study the effect of four important rotations being practised at the farm on the fertility of the soil, and it was found that the rotation most recuperative helped in the increase of available nitrogen. It was proposed to study the effect of all the rotations on soil fertility, but owing to the partition of the Punjab, the work could not be continued any further.

(5) *Availability of plant nutrients.*—The ultimate object in all agricultural operations is to increase the availability of plant nutrients in the soil. This may be done either by the incorporation of plant food materials in the form of manures from outside or by rendering the unavailable plant food materials already present in the soil in an available form. For whatever operations are followed the increase in yield and consequently soil fertility will correspond directly with the plant, food material that is made available in the soil to the plant.

The fertility of the soil may be improved by the addition of the following manures :—

1. Farm Yard manure.
2. Compost.
3. Green manure
4. Organic cakes.
5. Artificial fertilizers.

The artificial fertilisers can act readily but the other types of manures take sometime before their nutrients can be made available for plant.

The effect of different types of manures on different types of soil under varying conditions of climate and temperature in affecting soil fertility is again a very complex factor. This work which relates to agronomic experiments has formed the subject of an important report recently submitted by Dr. A. B. Stewart. The problem is vast and can only be tackled from different aspects in the Provinces. Manurial experiments have been going on in certain provinces for a number of years but no conclusive results have been obtained, as in all other

experiments, the soil factor was completely ignored. The new scheme must lay stress on the study of soils as an important factor in soil fertility and consequently crop growth.

(6) *Microflora.*—The micro-niological activities of a soil is a contributing factor towards soil fertility. It is, therefore, most essential that the microbial activities should be maintained at a proper level A vast amount of work on this problem has been carried out in outside countries but the most outstanding work on these lines that was carried out in the Punjab related to the inoculation of berseem. By introducing a proper strain in the soil it was possible to increase the yields tremendously and sometimes their effect was greater than those of manures.

The question of quality of crop in relation to soil fertility has not been studied systematically, as it is extremely difficult to lay down standards by which quality of a particular crop may be judged. In some cases it may be possible, whereas in others it is extremely difficult to define quality. The work has, therefore, not progressed much on these lines. However, this does not mean that the problem which is important. But it is the very complex nature of the problem which is defying the scientists. Ultimate aim in the investigations must be tc produce crops of better quality and quality must not be sacrificed at the expense of yields.

SUBJECT 1(b).

Review of the work done on the maintenance of soil fertility in India with suggestions for future lines of work with particular reference to the effect of the soil fertility on the quality of crop productions

A Note by Dr. J. K. Basu, M.Sc., (Cal.), Ph.D., (Lond.), F.N.I., Soil Physicist to the Government of Bombay, Province, Sholapur.

The problem of maintenance of soil fertility is as old as agriculture. In every country world over, men have realised that the yields of crops cannot be kept up at a high level if grown on the same land for long and certain basic principles of maintaining soil fertility were evolved through ages, which were ultimately incorporated in the local crop-husbandry. Although these practices differ considerably from tract to tract according to the nature of crops grown, soil and climatic conditions prevailing, and to the need of the people, the underlying factors of all these practices fall under three main categories (1) tillage operations (2) crop rotations and (3) manuring. These three points on which the super-structure of modern agriculture stands today, were also true in the agriculture of yesterday. Besides these, which has not been seriously thought of, until recent years, is the need for erosion control in the types of agriculture. It is, therefore, proposed to review the work done under the above four heads. The relevant literature on the subject is very vast and critical examination of the entire yield is not possible in a short note. The salient features of this all important subject will, therefore, be discussed with a view to re-orientating our present day ideas for building up a sound long-term agricultural

policy which will ensure self-sufficiency of food and other vital necessities of life for generations to come.

REVIEW.

It may be mentioned at the outset that certain aspects of this subject have already been dealt with by the author (1, 2) but some repetitions of the same will, however, be unavoidable. In treating the subject it is necessary to distinguish the three main types of agriculture prevalent in India in which the methods of management are widely divergent.

I. *Traditional Agriculture.*—This is the type of agriculture which has developed in different localities through ages. Though it has evolved as a result of past centuries of experiences it has remained backward due to ignorance, fatalistic attitude and dire poverty of the farmers. Although it is said that manurial practices were in vogue, even in the Vedic times (3) and that the early valley civilisations of Moheniodaro (4) indicated prosperous agriculture of those days, at the present time the conditions of traditional agricultural are appalling. Our yields are proverbially low when compared with other advanced countries of the world. The reason is not very far to seek. Organic manures (*e.g.* cowdung, farm refuse, etc.) are hardly returned to the soil as they are mostly used as fuel. The barest cultural operations are given in order to sow the seeds and hence the fields are always over-grown with weeds. Crop rotations are hardly followed, and continuous growing of cereals on the same fields depletes the soil completely and makes it prone to severe erosion losses at times. Although there are no reliable data available over long periods to show the deterioration in soil fertility under traditional agricultural practices in India it is hardly believable that the productivity of the land could be maintained over centuries through such exhaustive and erosion-permitting agriculture. (5).

II. *Improved, Extensive Agriculture.*—In the dry land and rain-fed tracts in India, improved agricultural technique has been introduced from time to time on Government Farms and Experimental stations as the sciences of agriculture progressed. Improved implements, better seeds, systematic manuring, crop rotations and pest and diseases control methods have definitely raised the agricultural yields of most crops, although the results of these promising methods have not filtered down to the average cultivators as yet. There is, however, considerable scope for improving the plan and design of field experiments in India as pointed out by Stewart (6). A critical examination of the past work is, therefore, very urgently called for.

III. *Improved Intensive Agriculture.*—Similar remarks apply in the case of intensive agriculture, although greater attention must be paid here regarding changes in soil under different systems of soil management. Under perennial irrigation, yields of crops can be easily pushed up by heavy manuring and irrigation but the changes of damage due to excessive salinity or water-logging are also great unless the lands are pre-surveyed for the intensity of irrigation they are able to stand (7). Thanks to the foresight of the Indian Council of Agricultural Research considerable amount of valuable data is now available on

irrigated crops lige sugarcane and paddy, which will definitely help to build up sound agricultural planning for the country in future.

Only a brief review of the work done on improved agriculture, both extensive and intensive, is presented below under four heads : (i) tillage (ii) rotations (iii) manuring and (iv) soil conservation.

TILLAGE.

A searching examination of the cultural methods in vogue should be made with a view to classify them into those that are actually required for maintaining crop yields at an economic level and those that are adopted as age-old practices. Sound agronomic experiments on tillage operations are few and far between in Indian Experimental Farms and those which have been conducted on proper statistical methods are also not carried out long enough in most cases. There is, therefore, considerable need for long-term co-ordinated research on tillage methods in main Experimental Stations in India on soil-climatic basis. A few of the outstanding results are, however, presented here for consideration. Observations (8) on deep ploughing in Black Soils, for example, point out that this operation is not altogether needed as a routine operation from the results of three years' experiments at Hagari (Madras) where deep ploughing and shallow ploughing yielded alike. Similar results were obtained at Sholapur (Bombay) where ploughing did not show any advantage over harrowing in increasing the yields of Jowar crop (9). Rothamsted experiments on wheat, barley and mangold also corroborate these findings as yields of these crops were not significantly affected by the use of implements working at different soil depths. Sewell (10) in a review of literature on dry farming showed that shallow ploughing (upto 7 inches) produced as good as deeper ploughing and concluded that the necessity of cultivation was only to kill weeds and maintain the soil in a condition favourable for absorption of rain water. It is, however, essential to conduct some long-term experiments to find out the optimum frequency of ploughing required to maintain crop yields at a higher level. From fairly exhaustive trials in the Punjab it can be concluded that where the standard of normal cultivation by the Deshi implements is high, the use of improved implements has significant effect on crop yields. For the eradication of deep rooted weeds, deep ploughing by tractor is likely to be necessary and the results from Assam also indicate that it may also be useful for paddy in some soils (6).

Interculturings have shown some advantages in controlling the weed infestations and in conserving soil moisture. At the Research Station at Sholapur, it has been observed that inter-culturings in certain months have yielded beneficial effects (11) in that the increase in nitrate content agreed with the increase in jowar yield. It has been observed that in the Godavari and Tanjor Deltas (12), it is usual to leave the land undisturbed after the harvest of paddy and to puddle it only after rains for the next crop of paddy. In some parts of the Delta areas, sugarcane is put immediately after paddy which requires breaking up of soil and other cultural operations but it is found on such soils, reduction in paddy yields after sugarcane. At the Research

Station, Padegaon (Bombay) it has been shown that the customary operation of "earthing up" can be dispensed with safely without lowering crop yields. (13).

ROTATIONS.

Good crop rotations have come to be recognised as one of the best method of improving soil fertility, yields and nutrient value of the crops all over the world. Much valuable data are available in the different Provinces and States in India on the subject but no recommendations are possible unless they are collected and critically examined on the basis of soil types and climate. It is also necessary that soil changes are studied carefully in this connection both under continuous cropping and rotations of crops and follow in order to assess the values of rotations on a long-term basis. At present the terms "Soil Exhausting" and "Soil Recouping" crops are used very vaguely and it is high time we know more precisely about the relative merits of various crops in this respect in different localities for building our existing rotations on more scientific lines.

Although details of cropping will have to be worked on the basis of long-term experiments on individual soil types, some interesting results are available from the Dry Farming Experimental Stations of the Bombay Province. At Bijapur, for example, cotton-jowar rotation has given 15 per cent. and 46 per cent. increased yields of jowar over continuous jowar in deep black and limy soils respectively (9). Again, at the same place jowar after fallow has increased the yield by 67 per cent. over jowar after jowar. Here reduced expenditure in a year of fallow and 67 per cent. higher yield after fallow together would compensate largely for the loss of a crop in alternate years. Similar promising results are also observed at the Research Sub-Stations at Jeur (Sholapur) and Chas (Ahmednagar) where following has almost doubled the yield whereas gram-jowar and wheat-jowar have both proved superior to jowar every year.

Mixed cropping *i.e.*, sowing mixture of legumes and non-legumes on the same field is a very common practice with the cultivators in India and should be carefully investigated at the experimental stations. Voelkar has pertinently pointed out "that it is quite a mistake to suppose that rotation is not understood or appreciated in India. Very frequently mixed crops are met with year after year on the same field and that this is the simplest form of rotation in which individuals in cereals and pulses get the fullest chance of exchanging places with each other.". (14). Mollison also mentions that system of mixed cropping so common in India is undoubtedly a successful and profitable method which probably has done more to uphold the fertility of the Indian soils than any other practices.

Coming to intensive forming practices considerable amount of reliable information on crop rotations is available in reports of various experimental stations in India and a few typical results of the Bombay Station are given here for illustration.

At the Padegaon Research Station the following two rotations are found quite successful in maintaining soil fertility :

Sann-cane-rabi jowar where green manuring is to be followed and cotton-cane-rabi jowar in case sufficient compost is available. It is to be noted that for the maintenance of soil fertility the rotation to be practiced depends to a large extent on the soil type. Thus the results to date indicate that on types F, G and H, a two year rotation is quite suitable whilst on types A, D and B (Padegaon Farm type) a three year rotation is preferable, and in types C and E, the rotation may have to be lengthened to four years.

Further the nature of preceding crops has also considerable effect on the yields when sugarcane is grown on different soil types. Thus the cane yields after various rotational crops receiving compost at the time of planting show that rotation with groundnut has proved most successful on three (A, B and G) out of four soil types. On "F" type, bajri has helped to raise the highest yields. Among the green manuring crops and fallows, sann has shown superiority over others on A, B and G types whereas Patada Shevra (Desmodium diffusum) topped the list on F types. The average yields of cane showed the following descending order of fertility : A, D7 G7 F (15).

MANURING.

The primeval principle embodied in the practice of soil management is the simple conception of replenishing the soil which becomes slowly and steadily depleted of its store of plant food due to removal of bumper crop harvest every year. Manurial practices comprise direct application of bulky organic manures like form yard manure, compost, etc., and the concentrated chemical fertilisers like super-phosphate sulphate of ammonis, etc., either singly or in combination to the main crop or through a preceding crop (either a green manure or a catch crop in rotation). The material available on the subject is so extensive that separate volumes can be written out on each of the major crops grown in India. The manurial reviews on sugarcane by Rege (16) on paddy by Sethi (17) and on cotton by Panse (18) are indeed very valuable in depicting the present position of the manurial work in India. Vaidyanathan (19) who has statistically analysed the manurial experiments conducted all over India upto 1933, concludes that of the effects of principal manures and nitrogenous fertilisers in general, ammonium sulphate has performed well in varying doses on all crops with the exception of cotton. Of the phosphates super-phosphate applied alone proved beneficial to sugarcane and paddy. On many farms a mixture of nitrogenous and phosphatic manures has done well on crops like paddy and wheat. Of the bulky organics, farm yard manure alone has been generally effective on all farms deficient in organic matter, otherwise its effect has been felt only in long-term experiments. In combination with artificials and oilcakes, it has usually given excellent results.

In recent experiments conducted at the Dry Farming Research Station, Sholapur (11) it has been observed that the yields of dry crops can be considerably pushed up by making up the soil deficiencies of badly eroded soils by the joint application of bone-meal, farm yard manure and cake in years of average rainfall. These soils are also found to be lacking in certain trace elements like Boron, Manganese and

recent field experiments on legumes have shown increased yields to the extent of 20 to 35 per cent. It is also interesting to note in this connection that the quality of crops has also been improved considerably in the case of groundnut and soya bean. Stewart (6) has observed that " although quite a number of instances of suspected Boron, Manganese, Zinc and other trace element deficiencies have been reported from as widely separate parts of India as the Punjab and Travancore, the study of trace elements in relation to plant and animal nutrition and crop production in Indian soils has received very little attention ".

The need for the application of bulky organic manures for sugarcane cultivation has been definitely proved at the Research Station at Padegaon (Bombay) where it has shown considerable deterioration in cane yields in plots receiving no compost but only top-dressings of sulphate of ammonia (15). The results of annual applications of various nitrogenous manures and fertilisers under irrigated conditions at the same station have demonstrated that farm yard manure stands out as the best in raising the levels of available plant food constituents and in building the best possible water-stable structure of soil when campared with other manures and fertilisers (15). In the course of a soil fertility survey undertaken over the Canal Zone of the Bombay-Deccan (20) it has been brought to light that sugarcane as grown by cultivator using large doses of organic bulky manures has been responsible for all round improvements in soil fertility excepting heavy losses of lime. Soil deterioration has only taken place when sugarcane has been grown with insufficient period of rest. Such deterioration has been ascribed to rise in C : N ratio of the soil, methods of whose reclamation have been dealt with in a separate publication (21). Green manuring is another aspect of manuring work which has received considerable attention in India and has been reviewed recently by Mukerji and Agarwal (22). This type of manuring has not proved very successful so far in dry farming, probably due to lack of moisture in the soil. In recent years field experiments have been taken up at Sholapur (Bombay) on the best technique of incorporation of green manure as well as of composted green matter with other farm refuse.

All the phosphatic fertiliser experiments conducted in different parts of India also require very careful scrutiny not only from the point of view of statistical working out of data but also from their inter-actions on various soil types and on different crops. Phosphate fixation is a common phenomenon on many Indian soils and the technique of its application should receive greater attention in future lines of work.

Quality of Crops.—Much work has not been done so far in India on this aspect. Vishwanath (23) working with farm yard manure at Coimbatore proved that in all respects crops grown with the application of well rooted manure superior in nutritional quality, cropping value and content of vitamins. The crop tried were jowar and *ragi*. He has also shown that well-rooted manure contains hormones or growth promoters similar to Bottomley's auximones in organic manures and neucleic acids and their derivatives. The animals fed on such grains were healthier and grains also were more viable. Quality of cotton lint has been studied by Nayak (24) who reports that Jayawant grown at

Dharwar yielded an optimum quality of cotton with five tons of manure but higher doses resulted in deterioration. Gulhati and Ahmed (25) showed that percentage of manure fibres in Cambodia cotton increased by applying sheep-dung with sulphate of ammonia. K. Bhusahanam (26) reported that of the various manures cattle manure gave the maximum outturn of cane but the quality of juice from no-manure plot was superior to that from other treatments. Basu and Tagore (27) working on alkaline soils of the Deccan Canals have shown that yard manure alone treated plots, although brought about lesser reclamation of sodium soils when compared to a mixture of sulphur and manure, improved the quality of *gul* to the maximum extent. The study of quality of crops should receive greater attention in all our future experimental work as it can make up in many respects the quantity factor of modern agricultural products which is falling far short of our present-day requirements.

SOIL CONSERVATION PRACTICES.

Reliable information is now available from the United States that over large parts of world's productive food growing areas, one-fourth of the agricultural land has been destroyed in little over a century by erosion and exhaustive farming. Even at the present time after drastic measures have been taken the Department of Agriculture of the U.S.A. estimates that productive top soil is being lost by erosion at the rate of 5 lakhs acres a year. Similar situations are prevailing in many other countries of the world but unfortunately no accurate data are forth coming for such losses of soil. Comparing America Jacks and Whyte (28) have written "the same phenomenon has appeared in long-established countries of the Orient, where the consequences of recent exploitation are super-imposed upon those of land's senile decay. Recent exploitation has been responsible for much of the catastrophic erosion that scars the foot-hills of the Himalayas but old-age has also left its mark over wider tracts of India in the form of sheet erosion which has been going on for centuries".

A technique for quantitative measurement of runoff and erosion from controlled plots was developed at the Dry Farming Research Station, Sholapur (1934) and at the Punjab Irrigation Research Institute at Madopur (1936). At the latter place losses showed marked acceleration of both runoff and erosion as a result of close clipping of grass cover, to stimulate in some degree the effects of over-grazing. At Sholapur, while natural grass vegetation gave only about half a ton of soil loss per annum per acre, close clipping accelerated the loss to over 17 tons per annum. Growing of cereals (jowar) enhanced the losses to more than 36 ton per acre per annum This works out to loss of 7 inches of top within a period of less than 30 years. Bennett (29) a well-known authority on Soil Conservation has written "according to estimates based on experience and intelligent observations, some of those who have lived in the country fear that if erosion is permitted to continue at the present rate, the situation in India may, in a few decades, be as serious as that in North Western China".

Recent erosion survey which is being conducted by the research staff at Sholapur over the scarcity tract of the Bombay Province indi-

cates that more than 70 per cent. of the cultivated land of the tract have partially or seriously eroded (11) Although this sample survey has been conducted over 35,000 acres comprising randum selected catchment areas, nevertheless it emphasizes the urgent need of erosion control measures in the cultivated lands of this tract. Probably a similar serious situation will be revealed if erosion survey is carried out over greater parts of cultivated areas in India. It may, therefore, appear to be surprising how cultivated lands are still able to supply our food requirements even today. The answer is given by Jacks and Whyte (28) as "where erosion has been going on for centuries, the ryots have evolved farming systems which, although not completely checking erosion, have kept it to manageable proportions ". Bennett (29) has also stated in his book on Soil Conservation that " from the Indus in the North-West to the Southern extremity of the Peninsula, bunding has been practised for hundreds of years for controlling erosion and conserving moisture ". Bunding schemes on more scientific basis have been carried out in the Bombay and Madras Deccans, in Central India and in the Punjab, for some time past. Only a brief account of the work done in Bombay is given below :

The progress of work done so far can be conveniently divided into three periods representing three progressive *phases* of it such as (A) individual *field scale work* done between 1928-40 (B) *group-scale work* done between 19|40-43 and (C) *regional-scale work* done after 1943.

Individual field-scale work.—This work was chiefly undertaken on the strong recommendations of the Royal Commission of Agriculture in assisting the farmer in controlling soil erosion. A small staff of two Bunding Officers for the whole of the Province was provided and their work was *purely advisory*. They were expected to examine the cases of individual applications from farmers who desired to put bunds in their own fields and to recommend to them suitable bunds and waste-weirs after personally inspecting the sites. More often the bunds were proposed according to the wishes of the cultivators and the only technical advice given was on the size of bunds and waste-weirs and the approximate cost.

Group-scale work.—Government had been slowly realising that such work of anti-erosion measures could not be sufficiently effective and successful if carried on such piece-meal scale. Just at this time Sir Ness Wadia who was inspired by extensive nature of such works done abroad (U.S.A. and Australia) offered a sum. of money on certain conditions and the Bombay Government formed a trust for undertaking larger-projects. In this scheme a group of cultivators had to agree to construct bunds co-operatively on a community basis. The smallest size of a project was fixed as contiguous and convenient area of 500 acres or more (upto about 1,000 acres). The work of actual construction of bunds was to be done by the cultivators and they were offered a subsidy of Rs. 5 to Rs. 6 per acre for " out-of-pocket expenditure " for such material as stones or skilled labour for the construction of waste-weirs. All the technical advice was given by the Government and an Overseer was provided to supervise the construction and other agronomic improvements that were to be introduced in the areas so

protected. The bunds planned were not strictly contour bunds but were generally running across the major slopes of the areas. The bunds were generally designed on straight lines with angular bents where required. Such a method always resulted in a movement of water along the bunds and accumulation of water at low-lying points. Under the circumstances waste-weirs were required to be provided for taking care of such excess water and the water that was found to enter the bunded areas from higher regions above the project area.

Over 30 such projects which were called Village Development Projects covering an area of about 25,000 acres were prepared and execution had started but out of these not more than ten were completed.

Regional-scale work.—This phase of the work which was started from April 1943 must be considered as the most effective phase although it may require modifications through research. The regional ideology is the secret of success for any effective prevention or control of erosion, and harnessing the water resources of a water-shed. No waste-weirs were planned as none were considered necessary. The general policy adopted was to construct one bund of 3 ft., height and 8 ft., base at every 6 ft., drop or at a distance of 250 ft., whichever was less. In uncultivated slopes. trenching was done on contours at a distance of 150 ft., and these trenches were planted up with suitable forestry. All gullies in the area covered by bunding and trenching were plugged up by stones or brush-wood, groynes so as to retard the flow of water in those gullies and reclaim silt at plug-points for cultivation. Over 5 lakhs of acre were thus bunded and trenched during the years 1943-46. The effects of these control measures on the building up of soil fertility are under examination at the land Improvement Research Station at Sholapur.

The outstanding feature of the modern outlook on Soil Conservation is the emphasis laid on the superior value of biological as compared with mechanical erosion control. The biological control of erosion by crop rotations consists in adopting a system of strip cropping *i.e.*. sowing close growing erosion-resisting crops in alternate narrow strip. laid across the major slope of a cultivated land. Such erosion resisting crops absorb most of the rain and prevent run-off of water and soil movement. This aspect of soil conservation although popular in the U.S.A. has been in the experimental stages in India. At the Research Station at Sholapur. a Contour Strip Cropping Scheme has been in operation since 1945 and the problems such as selection of the most effective erosion-resisting crops for different tracts, optimum seed rates of crops for obtaining maximum canopy and protection against soil erosion, optimum width of erosion-resisting strips at given vertical falls and effect of rotations of these erosion-resisting strips with erosion-permitting cereals on soil fertility, are being studied. Before adopting such biological methods of erosion control in different parts of India, it would be necessary to obtain similar data from different soil-Climatic zones of India. It is a line of work to which considerable attention should be paid as the methods are inexpensive as compared to mechanical methods of erosion control.

A RATIONAL APPROACH TO THE PROBLEM.

In the agriculture of the past very little attention has been paid to the soil conservation sides of the problem, the need for conservation measures being thought only necessary for specific instances. It is, however, assential now to emphasise the vital importance of being "ero-sion conscious" in all over agricultural practices as the present-day agriculture is nothing but "human interference with Nature's law" the biological balance being normally upset as soon as the natural flora associated with the soil-climatic complex are disturbed. To quote Bennett "Since the first crude ploughs uprooted the first square foot of sod and since man's axe first bit into virgin forest erosion of the soil has been a problem". The only remedy lies in the clear recognition of the land as a biological entity" capable of growth, development and decay like any other living organism. It can only live in association with its natural flora and fauna forming a natural non-eroding system. The agricultural methods should, therefore, be evolved taking into consideration the intrinsic quality and requirements of the soil and its environmental factors. The following suggestions are made for proper development of agriculture of tomorrow

The adoption of soil conservation practices as the basis of land-utilisation should be the first step towards a sound soil management. The foremost pre-requisite for successful farming is, therefore, to take an entire catchment or water-shed as a unit of organised planning for agriculture.

Farming-planning should be done by experts on the basis of land-capability survey taking into consideration all factors, such as soil, type slope, soil depth, erodibility and adaptibility of crop plants and farm animals of the tract. This will give us 5 to 8 classes of lands according to soil-climatic zones. For instance, in the dry zones of the Bombay-Deccan, the following five land classes are found suitable :

Class I :—Cultivable land with little slope (less than 0.5 per cent.) not liable to erosion.

Class II :—Cultivable land with greater slopes (0.5 to 1.5 per cent.) fairly liable to erosion.

Class III :—Cultivable land but with sharper slopes (1.5 to 3.0 per cent.) very erodible.

Class IV :—Not cultivable due to sharp slopes (greater than 3 per cent.) and poor soil.

Class V :—Not cultivable due to sharp slopes (greater than 3 per cent.) and no soil.

In future all our experiments will have to be done on all these land classes separately. For example, in Class I to Class III lands were arable farming will be recommended, increasing attention should be paid to research work on soil conservation practices as we pass from I to III. Thus while in Class I land, simple practices like contour cultivation, application of organic manures and introduction of legume crops every 2 to 3 years will be sufficient, in Class II lands, contour strip cropping with alternative years under legume and mulch farming

will be necessary. In Class III lands, much greater attention will have to be paid on soil conservation technique such as terracing, contour strip cropping, heavier applications of organics or putting to entire crop of legumes on occasions to build up soil fertility. In lands under Class IV and V necessary to pay more attention to "*ley*"-*farming* with or without controlled grazing. In Class V trenching and afforestation will help to rebuild the lost fertility in time.

It is true that research activities will be considerably increased when we look at the problem of maintenance of soil fertility on such multi-dimensional planes but there is no other way to save the world agriculture which is heading today towards a gigantic catastrophe.

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SUBJECT NO. 1(b).

"ORGANIC AND INORGANICS IN THEIR RELATION TO SOIL FERTILITY AND CROP PRODUCTION".

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This paper is promoted from the fact that of late much controversy has arisen as to whether organics or inorganics should form the source of amelioration of soil fertility. There has been as Ogg. remarked in his Presidential address in the agricultural Section of the last session of the British Association for the Advancement of Science. "Virulent and unprovoked attacks" on the practice of using fertilisers. In India also a number of articles were published particularly in the Statesman raising much controversy on the subject. It is therefore necessary to consider the matter in due regard to the available on the subject.

There are two schools of thought, one led by Howard and the other by the large number of soil scientists and agronomists. In this book on agricultural Testament Howard denounced chemicals and fertilisers. A large number of disciples has also gathered round him, and such books as Eva Balfor's "The Living Soil", Friend Sykes "Humus and the Farmer". J.I. Rodale's "Pay Dirt", King's "Gardening with compost and" and drummand's "Charter for the Soil" etc. are the outcome. In short their thesis divides into two.

The natural organic matter as obtained from Farm Yard Manure compost and so forth is all that is needed for soil fertility, and artificial

fertilisers are to be shunned as injurious. There is however a distinction in classifying the inorganic fertilisers. One such protagonist J. I. Rodale states (vide "Pay Dirt" page 6) that "for the purposes of this book, the terms chemical fertilizer or chemical shall be taken to mean those commercial or synthetic substances extensively used in the last fifty years in crop production which in combination with elements in the soil tend to produce insoluble salt residues that are detrimental to fertility. For instance, superphosphate, ammonium sulphate, calcium cynamid, nitrate of soda, and such combination as those populary labeled 8-10-6 etc., are poisonous sprays such as arsenicals. "According to him ground phosphate rocks, which are chemicals, strictly speaking, are not to be considered" "chemical fertilizers" for the purpose of his book. This distinction lacks consistency but it is a notable feature in the attitude of the sponsers of this school of thought. It may be stated that the insoluble salt residues referred to by Rodale are produced not only by the offending fertilizers but also by those tested by him and have received his blessings. However the main points of their thesis may be set forth as follows:—.

1. Nature is the supreme farmer. We should therefore leave fertility maintenance to Nature, simply ensuring the return to the soil of organic wastes.
2. Plants raised by chemicals are much more liable to pest and disease. Plant disease will cure itself when plants are raised on humus manure.
3. The nutritional value of compost raised crops is higher than that of chemical raised crops.
4. Conjoint animal-vegetable type of humus is the type we must provide

Their further contention is that—

Certain fungoid reactions are of fundamental importance to plant nutrition. Chemicals inhabit the growth and development of these fungi as well as of soil micro-organisms and earth worm.

If nature is the supreme farmer and if artificials are to be shunned, does it not logically follow that we should strictly depend on nature as we did in primitive days? Yet the man made agriculture has gone forward step by step only by artificial means. In place of wild mixed flora and fauna an earth's surface man has evolved new species which are nothing but prodigies and abnormalities from nature's view point. but man has produced them artificially and has adopted them for his special utility. Judged behind this background not only has agriculture discarded from its very dawn the simple path of nature but has followed a course which from the view point of Howard school should be called essentially and fundamentally unnatural. Agriculture involve soil treatment which nature never did before. It cultivates plants like potato, tobacco etc. which have travelled from one corner of the earth to other, it has developed machinery, tools, etc. all artificial, it has erected irrigation projects which in some cases have led to complexities like alkali problem which again can only be tackled by chemical and artificial means.

As regards the contention that plant raised by these means are more liable to pest and diseases, this is not borne out by fact. In India at any rate the use of artificials is negligible, yet last year a large part of wheat area was devastated by rust. In 1845 potato blight devastated Poland, Germany, Belgium, France and England. This occurred when fertilisers were not used. The interesting point here is that the very chemicals and artificials which are so vehementally condemned actually came to the rescue in another form. The discovery of Bordeaux mixture led to the control of the disease.

As regards the claims that "the nutritional value of compost raised crops is higher than that of chemical raised crops", this is not substantiated by facts. Ogg remarks that tests carried out some years ago, at the Dunn Nutritional Laboratories in Cambridge, showed that the vitamin-B1 potency of wheat grown at Rothamsted on plots which had received heavy annual dressing of fertilisers for over ninety years was at least equal to that from the plot which had received fourteen tons of farmyard manure annually over the same period. A similar result was obtained from barley from the classical Hoos field, and potatoes grown in a normal rotation which were tested for Vitamin C showed no difference whether grown dung or sulphate of ammonia.

Ogg states that a recent American experiment has compared the nutritional value of grass grown in a fertile soil well supplied with organic matter with that from a large-scale artificial water culture medium, free from organic matter. The conclusion reached was that in both cases the animal made good growth and gave evidence of nutritional well-being and that there was no evidence that the plants grown in the inorganic medium were deficient in any dietry essentials. A recent report (1946-47) of the Soilless Culture at the Hydroponic Research Centre at Kalimpog States that no distinction was noticed between a chemically grown plant and naturally reared one in point of flavour, nor have analysis shown any differenee in vitamin contents.

As regards the next point that we must provide conjoint animal-vegetable type of humus, no one will question the principle, but its limited availability imposes practical limitation on its wide-scale application.

As regards the point that chemicals inhabit the growth of soil micro-organism. Ogg states that careful tests made on the classical plots at Rothamsted have given evidence that the application of inorganic fertilisers even for many successive years has not had any deleterious effect on the soil micro-population.

But a mere increase in numbers of micro-organisms is not necessarily beneficial to the crop. Indeed if there is too much organic matter rich in carbohydrates. The increase in micro-organisms as may make so heavy a demand on plant nutrients such as nitrogen, as to compete with and even temporarily to strave the crop. At the same time microtrial activity originating from organic matter is largely responsible for improvement of soil structure.

Soil erosion is another aspect which has been ascribed to the use of the offendings artificials. Some times ago Mary Brown published a

letter in he Statesman in which she stressed that the danger from the wide-spread use of artificials in India is very great and as result of thousands of years of cultivation, huge areas could if fertility decline, become a 'dust bowl' that would make the U.S. Disaster pale into insignificance. It should however be stated here that in the 'dust bowl' of America the average annual consumption of fertilisers just before the war was less then 2 lbs. per acre of crop. Dr. Crowther has recently pointed out that the average consumption of fertilizers in Kansas, Colorado, and Oklahama, three of the worst States for soil erosion, was about 1 cwt. of sulphate of ammonia, 15 cwt. of superphosphate, and less than ½cwt. of muriate of potash per thousand acres. It will thus be seen that the incrikinating substances were far too small in amount to be responsible for such an enormous change. As a matter of fact, as Dr. Crowther observes' the dust bowl was caused by too frequent ploughing and not by too much fertiliser. The remedy will be found in more cover crops and leys and to establish these much more fertilizers will be needed. It may also be stated here that while erosion has been due to neglecting the humus factors in soil maintenance, it is not due to fertilizer practice. Unfortunately to the anti-fertiliser school this considered sufficient to launch on attack on the use of fertiliser, the effect of which is that in the long run the interest of agriculture really suffers. If crops which are not soil protective are grown repeatedly, the soil is mercilessly exposed to erosive action. Fertilisers cannot be condemned if they are misused. In fact the remedy in such cases of bad farming lies in giving the land proper rest, in initiating balance rotation and introducing suitable agronomic practices. It is well known that on account of large scale deforestation, bad water control, injudicious cultivation of slopes, overgrazing and other mal-practices, erosion of land has increased have been to an alarming extent in many parts of India. Yet India is a very artificials have been least used ; and if the non-application of artificials is any criterion of better production the notoriously poor yield of India would not have been the dismar picture of this country. Yet this state of affairs is due to the fact that in the large majority of soils the nitrogen status is very low whereas in others, phosphate, calcium or and potash are deficient. If India's production has to be stepped up we have to make up these deficiencies. Can they be done exclusively through organics or it can be better done through a balance and judicious application of both organics and inorganics in due regard to their respective requirements ?

The main point therefore that we should bear in mind that we should neither over estimate the virtue of one or over-emphasis vice of the other. We have to judge them in their proper perspective. For instance although organics have no doubt many virtues, there are definitely some which are refractory in the sense that they resist decomposition. These are, hair, hide scraping, hoif and horn meal, leather meal, wool waste feathers, shoddy and felt, scrap fur, silk waste etc Such materials have to be suitably treated by mixing with phosphatic rock and treating the mixture with Sulphuric Acid in the same way as Superphosphate is made. By this means its nitrogen is converted partly into Ammonium Sulphate and partly organic compound that the

readily transformable in the soil and made assimiable to plants. This is how innert material can be converted whether from organic or inorganic sources into forms furnishing valuable plant food ; yet obviously the method is nothing but chemical and artificial ; and if we do not adopt it we will be guilty of encouraging avoidable waste. Should we do it ? What we have to guard against is that there may not be any misuse or wrong use whether it is organic manure or artificial fertiliser.

At this stage it will be interesting to invite attention to a very important aspect regarding the possible ultimate fate of organic method in tropical soils. The way in which the changes undergoing in the soil occur, has generally been studied more under temperate than under tropical climate. This has led Dr. Keen during his recent survey of Middle East Agriculture to make a very revealing suggestion. He points out that the decomposition of organic material in the soil is essentially a process of oxidation and in Middle East conditions, much of its content of nitrogenous plant nutrients may be lost as gaseous products. He further states that unless some system of husbandry can be devised in which the crops can utilize a good proportion of the nitrogenous material, the advocacy of increased organic manuring as a means of increasing fertility is hardly justified. He states that indeed, a good case could be made out for the peasants' custom so generally condemned of using dung for fuel. If so small a proportion of its nitrogenous value is obtained by plants, owing to the rapid oxidation and disappearance in the soil, is it not better to use the heart of oxidation for domestic purposes than to lose it uselessly in the soil? And, as to the potash and phosphorous value of the dung, these mineral ingredients will remain in the ash, so the incorporation of this with the soil will be as effective as applying the raw dung.

Kenn's further remarks in this connection is also very interesting. He states poor fertility and erosion are generally attributed to lack of organic matter in the soil ; but this belief has been taken over from experience in temperate climates . In the Middle East organic matter decomposes very rapidly in the soil, and the equilibrium content is very low There is, as yet, no proof that any marked augmentation of soil organic matter is either necessary or possible ; indeed, the bulk of the evidence so far available points in the other direction. In any case, the amounts needed would be far beyond what the indigenous system of agriculture could provide.

Here it may also be pointed out that in a recent paper on the value of organic manures and inorganic fertilizers in tropical soils Das has dealt on the question from the available data with respect of Indian conditions. He cites evidence of Coimbatore soil in which cattle manure at rate of 10 tons per acre was applied for 20 years but the percentage of organic carbon in it was 74 per cent as against 0.59 per cent in the untreated soil. He has also given data of Pusa soils and as well as of Rothamsted and other soils and remarks that there is a considerable improvement in the status of nitrogen and carbon by the application of farm yard manure to the soils of temperate and cool climates, whereas very slight or hardly any improvement is observed in this direction in warm and tropical regions under similar applications of organic manures.

The suggestions of Dr. Keen and observations of Dr. Das emphasizes the need of approaching the problem from a new angle.

Here attention needs also to be invited to another relevant point viz., of compost. In the 1945 Session of the Crop and Soil Wing meeting in New Delhi it was stressed under Manures and Fertilisers (subject No. 2) that continued assistance from the Central Government is necessary for conversion of town refuge into manure and manufacture of village compost till the use of these manures become an established practice for stimulating their utilisation. Recently a Compost Conference was held which also received the blessing of Mahatmaji.

At present a number of municipalities are manufacturing compost and attention is also being directed towards Sewage sludge as a manure. Dr. Ogg's remarks in this connection will therefore be very pertinent. He states that there has been much talk of compost and these are excellent as far as they go, but on a clean well managed farm, run on ordinary lines, the amount which could be prepared from the weeds and crop residues would be quite trival True, it would be possible to organise the production of crops for composting but the land and labour required for this would very greatly increase the cost of our food supply and reduce the area of land available for food crop. In India however compost is being prepared from plant refuse, town waste and like material. These raw materials by themselves do not involve any cost for their production, but their conversion into compost is no doubt a matter of cost. Then there is the question of transport, backiness of the staff and variability in quality. It is not known if the cost has been worked out and how it compares.

As regards sludge Dr. Ogg states that only limited amount of the plant food is recovered in the sludge, and a drawback to its widespread use is the cost of transport. Sludges vary a great deal in composition and even the best of those so far examined are inferior to good farmyard manure.

Finally it may be stated as so apt put by Ogg that "every scientific agriculturist realised the value of organic manures and advocates their careful conservation and fullest possible use." At the same time it is of greatest importance as has been pointed out by Stewart, neither to overstate the case of organic manures nor to minimise the value of mineral supplements. The general evidence to date shows that both have their uses and that they should be regarded as complementary in their effects. Dr. Stewart has also stated that it is sound policy to take every reasonable step to insure the return to the land of all organic waste materials likely to be of value as soil improvers and it is equally sound and necessary to make full provision for supplementing such materials with mineral and other fertilisers which can play a most important past in the improvement of soil fertility Jurged behind these facts there is hardly any justification of the attack an fertilisers. These attacks originate from prejudice based more on belief than on observed facts : belief is however no substitute for knowledge. Here a simple fact can be mentioned. Fertilisers can be profitably used in producing humus as for instance by phosphate manuring of legumes for green

manure. It is also overlooked that when a component like nitrogen is applied in the soil whether through oil cake, farmyard manure or Ammonium Sulphate it has ultimately to take the same form before it is capable of assimilation by the plant. In all these transformation takes place through the agency of microflora of soil. For instance in a large majority of cases nitrogen is assimilated in the form of nitrate. There are various sets of organisms involved in it and each is responsible for bringing their respective stages of transformation ultimately leading to nitrification or nitrateformation. Judged behind this context organic manure will necessarily take a longer time in reaching the stage of nitrification on which the others in a more processed form will speedily do. As a matter of fact the most widely used manure viz., farmyard manure as a source of nitrogen is considerably slower in its action and less effective than equivalent amounts of nitrogen in readily available and concentrated form. On the other hand response to fertilisers in some soils may be enhanced if they are used to supplement basal dressings of bulky organic manure whose response also depends on the degree of its decomposition, moisture content and initial nitrogen status of the soil.

We have to take into account that nitrogen is extremely widespread in India and can only be made good by such manures or fertilisers which will be in a concentrated form and whose transport cost will be least. Bulky organic manure cannot serve such purpose. What is therefore needed is that within the vicinity of the area where bulky organic or where transport charges are suitable, this type of manure should be used. In other green manuring supplemented with some fertilizers like superphosphate will serve the purpose. In still other ammonium sulphate has to be used. This is how we shall be able to bring a proper balance between soil fertility and crop production.

SUBJECT NO. 1(b).

Maintenance of Soil Fertility in India by M.L. Mehta,

Soil Survey and Land Development, East Punjab, Karnal.

In semi arid tracts like the Punjab the summer temperatures are very high. A very potent limiting factor in crop production is the lac of humus in soil. The maximum temperature even during the winter in the Punjab is high enough to burn humus at the soil surface. The methods so far adopted to replenish the humus content of the soil are:—

1. The addition of farm yard manure.
2. Burying green manure with furrow turning ploughs.
3. Leaf fall and decomposition of crop residues.

In all these three methods the organic matter added to the soil remains more or less near the surface. Even green manures burried with the help of furrow turning ploughs keep within first six inches of the soil surface and with subsequent ploughings humus is brought to the surface to be decomposed and destroyed very readily. The result has been that, whereas crop residues, the farmyard manure and green manures

have given active response in the form of increased yields, the effect does not last more than one or two crop seasons.

In the year 1946 and 1947 experiments were carried out in different parts of the Punjab representing different soil conditions with varying rain-fall. In these experiments comparison was made in yields of wheat between the following treatments :—

i. Green manure burried one foot deep in the soil.

ii. Green manure burried with the help of a furrow turning plough, the green stuff lying within six inches of the natural surface.

iii. No treatment of control.

The results at all these places were significant and showed that the yield of wheat in plots where green manures was burried at a depth of one foot form the natural surface gave the highest yields. This was approximately 100 per cent. more than plots in which green manure was burried with the help of furrow turning ploughs and 150 per cent. more than plots in which no green manure was added. An examination of the field after first wheat crop showed that the majority of the green manure was still in tact and was decomposing at an extremely slow rate. From this the indication is that the humus store in the soil where green manure is burried at a depth of one foot from the natural surface is more or less in exhaustable atleast for another ten years or so. It is expected that the yields from these plots will continue to be high for several years. It will be realised therefore, that even though the process of burying green manure at a depth of one foot is tedious and expensive for the Zamindar the gain in the form of increased yields for a series of years is several times more than the cost incurred.

The most suitable crop for green manure is Jantar (Sesbania Aculeata) also known as Dhincha. This is a very quick growing plant. It belongs to the Leguminosae family plants of which are known to fix nitrogen from the atmosphere into the soil. Previously the plant has been used for providing temporary hedges in newly built houses. Its use as green manure is only recent and the important part it plays in increased food production is worthy of notice.

Seed is sown broadcast at the rate of 60 lbs. per acre. The only preparatory tillage required is one ploughing with a country plough. Jantar can stand a certain amount of salt and fairly high degree of alkalinity in the soil. The seed germinates within a week and when the plants are three or four inches high first watering should be given, subsequent waterings can be as few as can be spared or as frequent as desired. Jantar can stand drought and heavy waterings. When the plants have attained the height of 4½ feet, a cutting should be taken and cut plants utilised for green manuring in an adjoining field. If reasonable acre is taken of the crop after its first cutting, it becomes possible to take a second cutting after another 6 to 8 weeks. This second cutting can be utilised for green manuring a second adjoining plot. After cutting the crop is left to manuring and form seed. When the crop is matured, it gives a yield of approximately 8 maunds per acre of Jantar grain and about 200 maunds of Jantar sticks.

Jantar sticks are soaked in water for a few days and the fibre from the stick is peeled off. This fibre is used for making ropes.

The residual sticks are used either in making chhappars or as fuel. At Chakkanwali Reclamation Farm it was noticed that after the harvesting of Jantar considerable quantities of cowdung are releaed by tenants to be added to the manure heap.

From the experiments carried out both in the laboratory and the field, it has been noticed that during the disintegration of Jantar stalks and leaves when used as green manure, considerable quantities of gases are evolved. Of these carbon dixoide is one. This helps in reducing soil alkalinity and soil toxicity. Under certain conditions evidence of generation of sulphuretted hydrogen is obtained. Sulphuretted hydrogen is a strong agent for developing an acid medium which again is helpful in bringing the alkaline soil to more congenial conditions for plant growth. In terms of money, cultivation of Jantar can be depicted in the following manner:—

1	Portion of the crop	Value	Remarks.
		Rs.	
1	Two hundred maunds of green crop a as first cutting to be used as green manure	25	In the Thal it finds a ready sale for goats and sheep to graze. It has been possible to sell green crop at Rs. 50/- per acre per cutting.
2	Two hundred maunds of green crop as second cutting to be used as green manure	25	
3	Eight maunds of Jantar seed at Rs. 10/- per maund	80	Jantar seed is at present in great demand.
4	Fifteen maunds of Jantar fibre at say Rs. 10/- per maund	150	Jantar fibre makes very good ropes which find a ready sale in the market.
5	Two hundred maunds fuel at say annas 4 a maund in the village ..	50	
	Total value of an acre of Jantar crop	330	

ITEM NO. 1-b.

Effect of manuring on nutritive quality of crops.

(Note by S. V. Desai and W.V.B. Sundara Rao)

The end products of plant metabolism which nourish and sustain the animal and human body are controlled by soil conditions and the system of manuring. The poor conditions of the work animals and the low yield of canes in Bihar, Orissa and Malabar are reflections of phosphate deficiency in these soils. Ramiah (1932 Ind. J. Vet. Res.) finds

that pastures of spear grass (Andropogen contortus) at Hosur have a shortage of calcium and phosphoric acid, and that a mineral supplement of lime and bonemeal to the rations of cows and calves was distinctly beneficial. The influence of manuring on the nutritive value of crop received attention at Coimbatore, Coonoor and elsewhere and the work done on this subject has opened out vast possibilities. The vegetation and animal nutrition experiments carried out by Vishwanath and Surayanaryana (1927-Mem. Dept. Agric. Chem. Ser, 9 : 85 Indian) and Mc Cawson (1926-Ind. J. Aled. Res. 14 : 351) show that certain millets wheat, and rice grown with cattle manure possessed better nutritive value than crops grown with chemical fertilisers or with no manure and that crop grown with chemical fertilisers was superior to crop grown on anmanured soil. The newer knowledge of plant nutrition shows that quality and quantity can be combined by rational manuring and emphasizes the importance of organic manures in crop nutrition, especially to Indian soils which are notoriously poor in organic matters.

2. While soil is one of the primary factors in determining the composition of the plant growing thereon, other factors e.g., climate, the maturity of plants, the number of cuttings and the variety are also important. It has been shown that fertilisers can effect very materially the composition of the plant and when it is ecconomical, fertilising the plant is probably that best means of correcting a mineral deficiency in animals If this is not done mineral supplements must be fed to the animals.

3. It has been shown that plants produced on soils having a deficiency of one or more nutrients are of lower biological value to animals than are those where these elements are not lacking (Albrecht and Smith 1942—Soil Sci. Soc, Amer. Proc. 6 : 252). Digestion trials have shown that the feed efficiencies and utilisation of minerals vary widely for forage produced on different soils (William et. al. J. Nutr. 1940 : 19 : 251 : 20.391). Data showing the effect of soil treatments on the vitamin content of crops are none too consistent. It is probable that methods and techniques in making analyses are not yet sufficiently standardised for reproducible results in the hands of different analysis. However many of the data indicate that where crops are grown on soils containing a well balanced supply of plants untrients or where conditions are optimum for plant growth, the vitamin content will be amply high. The excessive use of single element fertilisers or of unbalanced fertilisers on crops, may result in plants of low biological value as those produced with a deficiency of the same element. Smith and Albrecht (1943-Soi. Sci. Soc. Amer. Proc. 5 107) presented data and demonstrated that forage and green from the same soil given different treatments have varied widely in their capacities to produce animal gains.

4. When the chemical composition of the feeds was changed by the different soil treatments, the ainmal response was not correlated closely enough to warrant the acceptance of the chemical analyses as an index of nutritive value. There is a strong suggestions that differences in feeds are brought about by soil treatments other than those commonly measured by standard methods of feed analyses. Only through assays with animals can these differences be determined.

5. On a soil low in lime and phosphorus, addition of phosphorus along increased the efficiency of forage when fed to lambs. When limestone was added in addition to phosphate, the nutritive values of hays were further improved.

6. The addition of any plant nutrient to a soil, without regard to the ammount applied, as related to the kind and supply of nutrients in the soil may not always give feed of improved nutritive value. Evidence is presented by Smith and Albrecht (1943—Soil Sci., Amer. proc. 7) where the addition of fertiliser and lime brought about an unbalanced nutrient condition in the soil which actually resulted in crops of lower efficiency, than where no nutrient additions were made.

7. Investigations conducted at the Imperial Agricultural Research Institute, New Delhi (Scientific Reports of the Institute for the years 1941-42 and 42-43) showed that albino rats had better growth when fed

on wheat raised at Pusa with organic manures than those fed on wheat from the plot receiving mineral manure. Studies at the same institute Scientific Reports of I.A.R.I. 1944-45) showed that berseem crop grown on Delhi soil after manuring with super-phosphate only, stimulated the growth of rabbits to the greatest extent and the crop raised with sulphate of ammonia plus superphosphate plus sulphate of potash (N-P-K) was not so greatly stimulating but it was better than the unmanured crop. The crop manured with phosphate alone proved better than the crop manured with the N-P-K, probably because of the higher percentage of P_2O_5 in the form than in the latter.

8. The functions of the different nutrients in plant metabolism are not well known where deficiencies exist, it is possible that some organic compounds highly essential to animal growth might not be synthesised within the plant and thus result in the feed of the lower nutritive value. Since all results indicate that feeds produced under well balanced fertility conditions are usually most effectively utilised by animals, it is not unreasonable to believe that excess of some element also prevents the synthesis of these compounds essential for animal growth or that it might cause compounds to be formed that would be injurious.

9. All these results point to the necessity of knowing the fertility properties of the Individuals soils. If nutritious feeds are to be produced for animal and human consumption, then, the soil on which they are grown must contain not only all the proper elements for plant growth but these must be presented by the soil in the proper ratios also. It is only through proper and intelligent management that farm acres can be made to produce high yields of quality products. On soils of low productive capacity the soil treatment can be expected to give benefits in addition to those of merely increasing tonnage, yields. The full values of these treatments however, cannot be measured as yet without the use of animal assay. It is suggested that wherever possible manurial studies should be supplemented by animal assay studies to valuate the effect of manuring on the quality and quantities of crop.

APPENDIX—II.

Notes read at the meeting on subject No. 2.
By.—

1. Dr. Sham Singh.
2. Mr. M. Pradyumna Singh.
3. Mr. K. C. Naik.
4. Mr. Ram Surat Singh.
5. S. Bal Singh Bajwa.

SUBJECT NO. 2.

The Importance of Rootstock to the Standardisation of Fruit Tree Material.

By

Dr. Sham Singh B.Sc. (Agr), Ph.D. (Bristol), Assistant Fruit Development Adviser to the Government of India.

Introduction.

Fruit trees are almost invariably built up from two distinct parts : the sub-aerial portion, or rootstock being chosen primarily for its relative capacity to grow, and the aerial portion, or scion, with particular regard to the variety and quality of the fruit required.

The rootstocks may have one of the two widely different origins. They may be produced from seeds which are genetically miscellaneous in character or from layers or suckers which, of course, are rooted stems. The former may be called 'miscellaneous seedlings' and the latter 'vegetatively propagated rootstocks.' All the rootstocks of one variety when raised by the latter method are of uniform genetic constitution while those raised from seed must necessarily very in genetic built-up except in the case of polybryonic species.

A vegetatively raised rootstock is a rooted stem and, in practice, the scion variety is always placed on to the stem portion of the rootstock thus leaving a greater or less length of the stock stem between the scion proper and the absorbing root system. When propagating on to seedlings, however, two methods may be employed. The one most commonly adopted is to insert the scion variety on to the stem of the stock by the same method and in the same way as that adopted with the vegetatively raised rootstocks. This method, therefore, also leaves a piece of stock stem between the scion proper and the absorbing root system but in this case the stem pieces are of miscellaneous genetic condition and origin. Another method of propagation followed chiefly in case of apple is that known as "bench grafting" in which the scion variety is placed directly on to the root part of the seedling rootstock. By this method, therefore, there is no functional stem in the tree other than that of the scion variety itself. These differences in method of propagation are stated because they are fundamental to an understanding of the issues which arise directly from the two-fold structures of the tree and the consequent reciprocal relationship between scion and rootstock.

Need for standardized material.

The prominence that is attached to the question of the rootstock and scion relationship has arisen mainly from the demand by Research Station more particularly in England—for 'standardized material' for use in fundamental investigations into such questions as pruning, manuring, fruit quality, etc. etc. This demand has been intensified of late by the recent advances in statistical methods and the fact that in all field investigations involving the use of fruit trees the amount of ground available often limits the number of trees to the bare minimum necessary in order to obtain reliable results.

The use vegetatively raised rootstocks.

(a) *Effect of rootstock on scion.*—In order, therefore, to satisfy the demand of the Research workers for standardized material, colonal vegetatively raised rootstocks were made the subject of intensive study and research by the Research Station at East Malling. This was naturally based upon the *a priori* assumption that miscellaneous seedlings, being different in their genetic built up will, of necessity induce differences in growth rate and cropping etc. of the scions worked on them. This work has now been in progress since 1912; Hatton and his fellow worker having published their results from time to time as information becam available (1,6,7,8,9,10,11,14,15,23,24). The general conclusions deriveo from the above investigations carried over a period of over 10 years may be briefly summarized in the words of Hatton and his collegues to th effect that 'A scion variety budded upon distinct varieties of vegetative ly raised rootstocks behaves very differently both in vigour and productivity'.

The rootstock work at East Mailing has tended naturally to focs attention more particularly upon the influence which the different root stocks may have upon the growth and productivity of the scion variety. In fact this has been the main line of investigation both at East Malling and at other centres where rootstock investigations have been started as a result of the work at East Mailing. It is established, therefore, that in certain conditions, a rootstock may profoundly modify growth and cropping of the scion but the degree of this influence may vary in different climatic and soil conditions.

(b) *Effect of scion on rootstock.*—More recently, however, attention has been called to the influence which the scion variety may have upon the growth and morphology of the rootstock. Swarbrick and Roberts (18) in particular, directed attention to this aspect of the problem and they have shown quite clearly that in certain conditions a scion variety may so completely dominate the growth of a rootstock subsequent to the time of union as to impress upon it a predictable morphology or 'character' This effect may be shown in the amount of root, its direction, the colour of the roots and their general appearance. Hatton and his fellow workers (10) at East Malling had previously noted an effect of scion upon rootstocks but have regarded this as of much less importance than the effect of rootstock on the scion. In any case these workers have concluded from their investigations in stem-worked trees that the effect of a scion upon the rootstock is purely quantitative in character and that 'stock types retained their characteristic branching regardless of the scion variety upon them' (1.11,24).

The contradiction between the above two groups of investigators is more apparent than real and is almost certainly due to differences in method and material employed. Hatton and his associates used almost exclusively the vegetatively used rootstocks—which are in fact rooted stems—and scion varieties that are not outstanding in their effect upon root character. Swarbrick and Roberts (18) on the other hand, used one year old seedling root pieces and scion varieties which by common consent and experience are shown to exhibit this influence in a marked

degree. The work of Swarbrick and Roberts has clearly established the importance of the effect of scion upon rootstock notwithstanding the published work of Hatton mentioned above (1,11,24).

Instances of scion influence on rootstock in case of citrus trees have also been reported by different workers. Hass and Halma (5) found that the Magnesium and Calcium contents found in the bark of the rootstock vary according to the scion variety worked on it. Halma (4) found that lemon grafted on the sour orange effected a change in the inherent form of the root system of the latter, Hodgson *et al*, (13) demonstrated that scion stock influences are reciprocal in nature, the scion either invigorating or dwarfing the root stock development, while Tanaka (21) and Brown (3) have both demonstrated that root development in respect of habit of growth, colour and vigour varies according to the scion variety used.

The scion|stock Relationship.

The available evidence points to the fact that the performance of a budded or grafted plant is an expression of the reciprocal effect of the two symbients. On this basis rootstocks have been designated as vigorous or dwarf etc. but since the vigour of different scion varieties and species on one of the same rootstock is known to be different (8,16) the terms vigorous and dwarf must be regarded as purely relative. Not only this, the recent findings of various workers (2,16,17,20) show that a scion variety has apparently an inherent growth capacity which it normally exhibits, a capacity which may be dwarfed very considerably but apparently may not be increased beyond a very small amount. This conclusion leads directly to the suggestion that in all cases, where rootstock influence is a limiting factor to tree size, it is of a dwarfing character. Roberts (16) goes even as far as to suggest a classification of rootstocks on this basis. According to him the so-called vigarous rootstock of Hatton (12) are really neutral since they do not in any way limit the free development of the scion. Dwarfing rootstocks, on the other hand, are dominant since they do not allow the scion to develop in its natural capacity.

The use of miscellaneous seedling rootstocks.

The incidence of variability in orchard material and the possibility that the use of seedling rootstocks tends to increase this variability on the one hand, while on the other use of clonal rootstocks reduces it, is a subjects of considerable importance in horticultural practice and theory, and the cause of not a little difference of opinion. At any rate, it is generally accepted that the use of miscellaneous seedlings as rootstocks will result in variable tree growth and performance. There is also a very strong tendency when discussing variability of material to under-estimate factors other than rootstock and certainly notwithstanding many references in literature (19).

In a recent publication Swarbrick *et al* (20) have shown beyond doubt that there is no essential difference in the variability of materia between the trees worked on to miscellaneous seedlings and those one some clonal vegetatively raised rootstocks. The variability was so small that the differences due to rootstocks were neglible. The evidence presented

effectively disposes of the argument that the use of miscellaneous seedling rootstock is certain to lead to more variability than the use of clonal rootstocks, in so far as three size is concerned and over the initial period of four years after planning. It is clear, therefore, that the use of miscellaneous seedlings will not always prejudice an experimental results.

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SHAM SINGH,

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SUBJECT NO. 2.

"THE IMPORTANCE OF ROOT STOCKS IN THE STANDARDIZATION OF FRUIT TREE MATERIAL"

Note by

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Before embarking upon the main discussion, we must first of all know what is meant by rootstock and why it is necessary to use it at all in fruit trees. One of the methods of propagation of fruit trees is known as graftage which includes various forms of budding and grafting. In either case a part of stem of one plant known as the scion is joined through man's intervention, to a rooted plant known as the root-stock. The combination of the stock and scion is called a scion and the effect of the one on the other is referred to as scianic effect. The use of rootstocks to permit rapid multiplication of fruit tree types possessing desirable characteristics dates back from very early times and in all probability the first stocks used were mostly seedlings of the same species as the scion variety. But it has also been long realised that by utilising stocks of different species the habits of growth and fruiting of scion varieties may be modified and altered in various advantageous ways. Thus for centuries the Quince has been used in Europe as a dwarfing stock for pears to encourage precocious fruiting and to adapt the pear trees to garden culture. While for apples the vegetative propagation of dwarf clones such as paradise has been developed for the same purpose. In comparatively recent times the expansion of fruit industry into many new regions of widely differing soil and climatic conditions and the requirements of the modern markets have led to a large increase in the number of fruit varieties grown. Many old varieties have disappeared been discarded or superseded by new ones in order that the needs of each particular locality may be as adequately served as possible. Similarly new root-stocks have been required not only for such purposes as dwarfing but for the adaptation of these new varieties to such factors as winter cold, drought, soils, alkali and resistance to diseaese and pests. The classic example in favour of the use of root-stocks is the one of European grape which was on the verge of being wiped out by an insect called Phylloxera which reached Europe along with American grapes. Only by grafting European grapes on American stocks which were immune to the attack was the European grape industry saved.

It is thus apparent that the artificial union of scion with stock is invariably advantageous despite the knowledge that no single root-stock is compatible with all scion varieties and that there are many cases where the results range from partial success to utter failure. However we are not here concerned with the possible causes of incompatibility or the discordant association between a spices or variety used as a stock and another specie or variety used as a scion.

Our aim here is to discuss the pros and cons of the important role or otherwise which the rootstock in general play in the standardisation of fruit tree material. The question therefore naturally arises as to

why this standardization of fruit tree material has become necessary. To answer this we will have to fall back upon the peculiar demands of the modern statistician who has in the light of rapid advancement which the modern methods of experimentations have made, pointed out that until the research worker materially reduces to the minimum the total amount of variation which is made up of three parts viz. (1) Variation due to treatment, (2) Variation inherent in material, and (3) variation due to differences in position, he cannot and will not be able to bring out those finer effects of various treatments on his exeperimental trees which he thinks he shall.

This warning note have strongly appealed to the horticultural worker especially when he reviews with dismay the meagre accomplishments of the past generation. He has realised that something is really a miss not only with the methods of field experiments used in horticulture, but also with the material available for experiments. We will now proceed to review briefly some of the previous work ; the causes of failures of earlier experiments ; how the material has been improved and standardised in recent years and lastly whether or not employment of this material has been an adequate means to the end in view.

Brief Review of Previous Work :—

In the U.S.A. for example after 30 years of manurial trials at 28 different experimental stations it was realised that the results obtained were extremely small in proportion to the time, energy and expense involved and it became generally accepted that the field experiment methods as previously used were not likely to lead to acquisition of much knowledge of the nutritional problems of fruit trees. Earlier workers found that the experiments with fruit trees "exhibit errors from sources which do not generally affect experiments in agriculture, " and again Chandlers abserves "these field experiments have not yielded as valuable results as was expected of them". This he attributes to high variations and notes that although yield of treated plots was nearly twice that of untreated plots yet is not certain that the difference was due to treatment.

Causes of Failure:—

We will here confine ourselves to only one of the causes namely the source of error due to variation inherent in the fruit tree material. This inherent variability in a set of fruit trees is primarily determined by the way in which the tree is built. Three causes seem to be mainly responsible for the very variable material with which the earlier workers had to deal.

(a) *The Use of Seedling Varieties.*—It is a fact that practically no fruit tree can reproduce itself exactly from the seed because the differances between sexually reproduced seedlings very commonly occur and may be very small or very small or very great. The more highly developed the plant is and the more difference there is between the two parents the greater is the probable variation in the seedlings. Thus it stands to reason that with few exceptions, the use of seedlings is becoming exceedingly rare in horticulture. However where seedling are still

used, the variation is so great that such material is but of little value for any but the crudest of experiences which are at best a labourious and uncertain undertaking.

(b) *The use of Clonal Varieties Carelessly Raised.*—Use of seedling being deprecated, the horticultural worker started raising and multiplying plants from root and stem cuttings, layering etc. ; from a desirable mother plant, thus bringing uniformity in the off-springs. Even in such matrial variation were found. These were in many cases due to presence of "rogues" which went undetected or because the mother plant happened to be diseased and thus transmitted the same to its progeny.

(c) *The use of Clonal Varieties Budded or Grafted on to Seedling Stock.*—There was a time when buds wene promiscously selected from any part of a tree or trees and budded on to seedling stocks no matter how variable. Swingle however called a halt to the promiscous selection of buds especially in citrus and proved through many instances the value of bud selection not only from high yielding and quality trees but from individual branches of a tree in order to avoid bud selection from inferior limbs which not in-frequently appeared as bud mutations. While on the whole there is comparatively little evidence of inherent variations due to bud mutations in the scions which are the vegetative progency of clonal varieties, seedling rootstocks have been blamed as one of the chief causes of the enormous variation with which the worker of the past generation had to contend. Although numerous examples of variation caused by seedling rootstock are known there are few cases where direct comparison between trees on seedlings and those on standardised rootstocks have been made. Such Pomologists as Sax and Gowen, Hedrick and Anthony, Dorsey and Knowlton, and Anthony and Waring all agree that seedling rootstocks are the cause of much of the variation in the apple orchards. The same state of affairs existed in the pear, Cherry, and Plum orchards, complicated by the fact that some seedlings displayed incompatibility with certain varieties.. Webber also notes the probability of seedling rootstocks being responsible for high variation in citrus groves.

Improvement in Material.

It is thus quite clear that drastic measures were necessary if horticultural field experiments were to be of any practical value. The first improvement which has been affected has been in the material. Some workers have endeavoured to remove and potential source of variation in seedling root-stock altogether by propagating trees by vegetative means on their own roots but with many fruits this has been found to be of doubtful practicability, if indeed desirable. The standardization of rootstocks seemed, therefore, the most practical way in which to obtain greater uniformity. Hatton has shown not only how to raise such material but also the superiority of vegetatively raise root-stocks over seedlings which has enabled the reduction of the co-efficient of variation from as many as 50 per cent. to 70 per cent. In fertilizer trials where standardized stocks have been employed, it is seen that the responses to manuring of

a set of trees on one rootstock are quite different from whose of trees on another rootstock. This will not be the case if root-stocks were unknown and might lead to contradictory result as has been the case with most experiments. In apples for instance Hatton has been able to reduce the co-efficient of variability for most characters to the neighbourhood of 25 per cent. and he is hopeful that further reduction is possible if soil variations could be eliminated and the supply of clonal root-stock can be increased.

Difficulties in Standardization.

Although the importance of standardization of both stock and scion has been felt on all hands it is not possible of achievement in all cases. There are certain difficulties due to the occurence of the following groups of plants:—

1. There are certain tropical and sub-tropical fruits which are usually self-fertilised and are therefore naturally homozygous but this group is unfortunately the smallest and includes only one important crop the Arabian Coffee in which there still seems to be a difference in opinion as regards the amount of actual crosspollination taking place although the crops are reported to be even.

2. *Those which are cross-fertilized and therefore heterozygous.*—In this group are such fruits as citrus which can be propagated by budding and there are others like Bananas, Pineapples, and dates which are usually propagated from slips and suckers. As regards Citrus, definite varieties are known but the problem of seedling root-stocks has yet to be solved. One way out of this difficulty is the utilization of the phenomenon of polyembrony. It is possible to raise vegetative families from the seed provided the sexual embryos can be recognised and removed soon after germination. So far the efforts of the workers have not been crowned with success. Webber thinks that the sexual embryos are smallest and the weakest of the lot and these are present in small numbers in nearly every lot of citrus seedlings. Mauri on the other hand reports that in Poncirus trifoliata and Bigardia the sexual embryo is visibly the strongest and by eliminating the same a line of clonal root-stock plants can be obtained. Despite this contradiction the fact that such variants although invariably present, form but a small percentage of the total, makes it possible to select a lot of uniform seedlings through the elimination of every week and extra vigorous ones.

Some Trials with Standardized Stocks.—The note will not be complete without taking into consideration the opinions of other workers who have experimented with the standardized root-stock.

Kemmer E. states that few data available suggest that the variation in clonally raised stock are sometimes as great as seedlings

South Wick L.and Shaw J.K. tried the malling clonal stock in Massachusettes and came to the conclusión on the basis of variability studies that very little benefit can be expected from the use of clonal rooted trees in establishing and maintaining uniformity under those conditions.

Spink's G.T. compared the performance of apple trees on mixed seedlings of unknown origin with trees on clonal stocks and drew following conclusion:—

a. That size of trees upto five years of age in nursery does not appear to be significantly more variable on mixed seedling or on seedlings of four seperate varieties than on clonal stocks.

b. That grading of either seedling or clonal stock before planting in the nursery has not resulted in greater uniformity of the trees.

c. That trees in orchards six years old or less after transplanting were found to be equally veriable on clone stock and on single variety seedling stock.

d. That where mixed seedling stocks were transplanted entirely without selection variability was found to be greater.

Brase K.D. and Tukey H.B. state that the original nursery size of seedling root-stock play little part if any, in he growth of trees budded upon them nor it is considered that the genetic constitution of root-srock were responsible for growth made by trees. Retransplanting to a fresh site after the trees had been established in an orchard resulted in an equalization of growth in large and smaller trees and in masking of any possible inherent vigour of root-stocks.

Bligh R. D. reports that trials with East Malling clonal root-stock in Novasootai neither contradict the view that it is possible to ensure a definite measure of vigour, size and fruitfulness by the use of clones nor do they prove that the root-stocks are superior to certain locally selected root-stocks.

According to Upshall W. H. variability of apple trees at least in the early years can not be materially reduced by the use of clonal root-stocks and that soil conditions physical and chemical is a more potent factor in creating variability than stocks. So far the trees on clonal stocks have been less variable in fruit production but no less variable in vegetative growth than trees on seedlings.

In conclusion although it is clear from the above instances that the use of clonal root-stocks have not given uniformly outstanding results in many places, perhaps due to soil heterogeneity and at times have been superseded by seedling stocks nevertheless, in view of the growing appreciation that both stock and scion should be standardized for the improvement of various fruits gives a definite hope for the future. It has been noted that standardization as such is a slow process and requires considerable skill and patience. Also in cases where vegetative propagation is not possible, the process becomes all the more complicated and uncertain.

Till such time as variation due to treatment, variation inherent in material and variation due to differences in position has not been reduced materially, contradictory results and disappointment stares the research worker in the face. There seems to be only two solutions of the problem, (a) To stop all experiments and concentrate on the task of standardization alone, and (b) To maintain individual tree records where the material is extremely variable for a number of years and then begin differential treatments whatever they may be, on the basis of records of individual tree performance stretched over a number of years.

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Subject 2.

FRUITS.

Item 1.—Experience as well as the experimental findings prove that in most fruits the commercial importance of a variety is limited to a narrow range of environs. Innumerable failures on the part of fruit producers can be directly traceable to an inadequate appreciation of the aforesaid fact. As an instance, the famous Langra mango of U. P., Bihar and Bengal has failed to produce any crop of fruits in numerous orchards planted to it within the Province of Madras. Similary, scores of varieties introduced from other parts of India have proved to be partial or total disappointment to the South Indian fruit producers, so that the importance of selecting the best variety from among those already cultivated within the region, for raising future commercial plantations, becomes established. This fact does not necessarily belittle the value of introductions and trials in experimental plantations, but it does prove that large scale introductions of plants of different varieties from distant centres may mean but a risky undertaking.

2. From the above stated facts it follows that the work of crop improvement through breeding should be confined primarily to varieties of tested commercial importance within each region. Unless the performance of the varieties are tested adequately in a region, it may be futile to select that variety in any breeding project, for it may not even produce any blossom. In other words with a perennial crop like the fruit, which as shown to respond markedly to varying conditions of environment, breeding projects undertaken at one centre may largely be valueless to a country of the size of India, with all its diversities of environments.

3. In the case of the mango there are also certain other regional peculiarities which are pertinent to the point at issue. For instance unlike in other parts of India, there are certain areas within the Province of Madras where sizeable crops of mangoes are produced in off-seasons almost regularly. Furthermore, this Province is also in a position to place in the Indian market the earliest crop of mango fruits in any year. The exploitation of such early and off-season bearing tendencies is undoubtedly a matter of great economic importance. Unless the breeding projects are conceived in a manner to enable the accentuation of the above stated special tendencies by providing for the breeding work to be conducted amidst the peculiar environments in the Province, the results cannot be all that should be expected.

4. Passing to the next important commercial fruit of India namely the banana, here too the need will be manifest for breeding in varieties for the varied conditions of soil and climate, under which the crop is being extensively cultivated at present. The requirements of a rainfed Sirumalai banana of the Lower Palnis cannot but be distinctly different from those

of the intensively cultivated Poovan of the plains. Even so, the conditions of commercial cultivation of Neudrans on the lateritic hill slopes of the West Coast are bound to be not on all fours with those of the Chakkarakeli grown in the rich alluvial delta soils of the Circars. The breeding of varieties with special characteristics to suit every important soil and climate as are devoted to the fruit at present, may therefore be deemed to be of vital importance.

5. Instances can be multiplied to strengthen the aforesaid arguments. Particularly with citrus fruits and grapes, the peculiarities of soils and climates in relation to the production of these fruits are so strikingly different from those in most parts of the country that it is difficult to expect any material benefit from a breeding project located or pursued in centres outside the Province. If the policy of extensions and improvement of the fruit industry is to be based as it should be, on the principle that the optimum zones should be earmarked for such expansion and improvement and that the most economic and profitable varieties should alone be planted in commercial grovers, there that cannot be any other conclusion except that the crop improvement in fruits through breeding must essentially be done through the conduct of work in the most appropriate areas for the fruit.

6. On these ground and in view of the fact that the Madras Province claims at present the largest production in tropical and sub-tropical fruits and that several of these fruits are being grown under a diversity of soil and environmental conditions, it is suggested that in any breeding schemes of the future for fruits, the need for taking into account the importance and peculiarities of South Indian fruit industry, should be recognized.

Item 2 (*a*).—The question of standardization of rootstocks is of little or no significance to most of the commercial fruits of this country. Among the leading fruits of the country, the rootstock problem does not at all apply to the banana, while with the mango the question of standardization of rootstocks is yet one of largely academic value. This fruit is almost entirely raised in India on a miscellaneous basis as the monoembryonic seedling stock. Vegetative propagation of mangoes for use as rootstocks has been attempted in the past, but with results that are so disappointing that any further trials seem fruitless at least in the present stage of our knowledge. The only possible source of vegetatively propagated material for use as rootstocks therefore is the polyembryonic mango, which is at present found on any extent only in the West Coast of Madras Presidency. In this group of polyembryonic mangoes, there is little to be done by way of standardization, since the nucellar seedlings arising from the seeds have already been found to resemble the parents and are characterized by a homogeneity or uniformity rarely met with even in material raised by layering, cutting or such clones. More than the standardization therefore, the immediate question in the case of such mangoes is to test the rootstock potentialities of each of our polyembryonic varieties. Rootstock trials are therefore the real need at present with this fruit. If the banana and mangoes are thus left out and if in addition to these, the commercially seed-propagated fruits like the cashew, annonas, etc., and those that are exclusively raised by cuttings such as the grape

and pomegranates as well those raised by suckers, runners or slips as the pineapple, strawberry, etc., are eliminated, we shall have practically only certain insignificant areas left over to be benefited by the work of standardization of rootstocks.

2. Examined against the background of the Indian fruit industry as a whole, it would therefore, appear that the standardization of rootstocks is a relatively unimportant problem, and can well be considered after the more pressing lines of work of manifestly greater importance to the country's fruit industry are tackled. Rootstock standardization has been of vital importance to citrus industries and deciduous fruit growing industries like those of apple, pear and plum, and already very great advances have been made in the directions such that standardized clonal material or reputed and clearly designated varieties or strains of polyembryonic nature are now available to the producers all over the world. As a matter of fact the standardized Malling and Merton clonal materials as rootstocks for apples have already been introduced and are under trial in this country in several places, while the rootstock employed for citrus in this country are also those which have been worked upon in many other parts of the world and are also known to be polyembryonic. Since all these standardized materials are already available for citrus and deciduous fruits, what is now required is not a duplication of the work already attempted elsewhere, but the conduct of rootstock trials in various regions to determine the optimum stionic combination for our best fruit zones and for our leading commercial varieties.

3. Such rootstock trials as mentioned above were attempted once before under the aegis of the Imperial Council of Agricultural Research. These trials were designated as co-operative rootstock trials and were to be conducted simultaneously in several provinces. Material of some of the citrus to be used as rootstock in these co-operative trials were supplied from the Fruit Research Station, Kodur, to some provinces. It is not clear why these trials were abandoned and what stage the surviving trials have progressed. At any rate it is believed that these co-operative rootstock trials have not yielded yet the useful results expected of them But this need not mean that there was anything inherently wrong in the scheme itself. On the other hand, a well-planned co-operative rootstock trial, if conducted in several typical growing regions simultaneously and according to a set plan, can be invaluable in furnishing information in due course on the influence of each of the selected rootstocks on the performance of the leading cultivated citrus and in relation to diverse soils and climate.

4. Vegetative propagation of citrus rootstock is largely of academic value. For one thing, the age long experience of citrus producers in all parts of the world has shown that seed propagation is the best and most feasible for raising rootstocks, and is consequently adopted universally. Secondly, the shallow rooting habit associated with rooted cuttings and layers of citrus is another defect attributed to the vegetative propagation methods. Unlike in the citrus, however, clonal rootstock material has come to popular with some deciduous fruits like the apple, even though a large class of growers in many parts of the world still feel that crab or seedling stock is superior to clonal rootstocks.

5. Summarizing the position, it may be stated that—

(a) the standardization of rootstocks is a relatively unimportant problem in so far as the fruit industry in India is concerned ;

(b) it is of only academic importance even in the small group of fruits like the apple, pear, etc., which are commonly raised on vegetatively propagated rootstocks, because of the fact that standardized clonal material evolved in England and elsewhere are available for trial and use ;

(c) it is of no value in fruits such as citrus which are commonly raised on seedling polyembryonic rootstocks ; and

(d) the institution of a co-operative trial of rootstocks on a nation-wide scale seems important to determine the best stionic combination for each of our diverse conditions of soil and climate and to each of our leading cultivated citrus and possible the mango as well, provided only the polyembryonic seed material is used to raise the rootstocks.

MADRAS AGRICULTURAL DEPARTMENT, *9th December* 1947. — K. C. NAIK, *Fruit Specialist.*

SUBJECT NO 2.

A note on the importance of Root Stocks in the Standardization of Fruit Tree Material. (Mr. Ram Surat Singh).

Standardization of fruit tree material is equally important both to the experimenter and to the commercial orchardist. Its importance to the experimenter is so obvious that it hardly needs any elucidation. Standard fruit tree material is the basic foundation on which the experimenter depends for his results, which in order to be comparable must be derived from as uniform as material as possible. All the disturbing factors have to be eliminated in order to arrive at true results. While it is possible to effectively eliminate the factors of soil variations etc., by means of randomisation, it is very difficult, if not actually impossible, to eliminate inherent variability in the live material being used, which if not standardized, manifest the inherent variability in such a complex way that it is not possible to control it. The experimenter must, therefore, have an absolutely standardized material to start with.

To the commercial orchardist also, standardized fruit tree material has the same importance, although it may not appear so obvious. Hodgson, taking a census of orchards in California, was able to divide the trees of most of the orchards in three different categories viz. entirely unprofitable, the self supporting, and the profitable ones. He found that the percentage of unprofitable trees in an orchard varied from 13 to 32, of self supporting trees from 19 to 42 and of profitable trees from 68 to 26. It will be seen from this analysis that even in

fairly good commercial orchards of california, one tree out of every three is either unprofitable or only self-supporting.

Similarly Bachelor found that there was a difference of practically 109 per cent between the lowest and the highest yielding plots of a citrus plantation, although every possible care was initially taken to plant out only uniform material.

If such is the case in the orchards of a highly advanced country like U.S.A., it will be no exaggeration to say that, under the present conditions, about 50 per cent. of the trees of commercial orchards in this country are either just paying or unprofitable. The benefit which can be derived by standardization of fruit tree material and by having only the profitable trees in the orchard is thus apparent. By controlling this single factor, the production of fruits in the country can easily be doubled as shown above.

In order to know how this can be done, it is necessary to study the causes of variability and to find out which is the most potent factor causing it and how this can be counter-acted. Unfortunately little work on these lines has been done in this country, but evidences from work done elsewhere go to show that *Root-Stock* is the most potent cause of variability. Thus Webber, noting the existence of variation in yield of trees of the same variety, in the same orchards, planted at the same time and cultivated alike, considers it likely to be due Primarily to (a) variations inherent in the buds (b) different kinds and characters of stock used, (c) the character of the union obtained in budding and grafting (d) difference in environments and (e) accident.

Out of these he believed that the influence of Stock was fundamental. He has described an experiment in which the seedlings to be used were graded before the scions were worked and he found that even after 2½ years, when the budded plants were growing in the orchard, they had the same relative size as when originally dug in the nursery, i.e., the plants on smaller stocks remained smaller and those on bigger ones were bigger.

An examination of other casual factors led him to believe that the most important cause of difference lay in the stocks.

In the ordinary course most of the causes leading to variations in size and productivity of trees of an orchard can easily be removed. Usually, there is not much variation in the structure and composition of the soil of an orchard Whatever little difference there may be can easily be removed by the addition of organic manures, fertilizers, and even soils of different textures.

The variation inherent in the buds can be eliminated by selecting mother trees of known performance. Similarly the character of the union in budding and grafting can be made uniform by a little care at the time of performing the operation. Environmental conditions do not materially differ in the same orchard. So that all the above factors are not difficult to control.

To have uniformity in the characters of the stocks, however, is a problem, especially in those cases, where the stocks cannot be propagated vegetatively. In the case of temperature fruits where propagation of Root Stocks by vegetative methods is comparatively simpler, it is quite possible and economic to evolve clonol Root-Stocks and propagate the manure of plants required for stock purposes vegetatively. These will, naturally, have more uniformity and scions worked on these are bound to behave in an uniform manner in the orchard, provided other conditions are controlled, In the case of most of the Root-Stocks of tropical and sub-tropical fruits like citrus and mango etc., his is, at present, no possible, and in order to have Root-Stocks of uniform performance, it is necessary either to evolve suitable economic methods of vegetative propagation of these stocks or to standardise them by other means such as selection. Both these possibilities have to be studied for individual fruits.

Among the Root-Stocks in common use for citrus, it is known that there are different variations, types or varieties within each.

In examination of a stock nursery, Webber, Mertz and Thomas were able to select out 16 of different types which were remarkably distinct from each other in character and size of growth, branching, foliage and other important characters, leading to the belief that the stock raised from seeds of the same type were actually made up of a very large number of widely different types of different genetic constitution. In order to get over this variation, it is recommended that whenever any seedling is found to be of a good stock type, it should be propagated by buds and sufficient number of trees so propagated should be grown in order to supply all the seeds required.

The work of Webber also goes to show that prebudding selection in the nursery, in order to eliminate the variant seedlings, is more effective and economical in producing uniform fruit tree material than post-budding selection.

Fortunately the phenomenon of Ploy-embryon is quite common in citrus varities, the percentage of apogamic embryos varying from 40 to 100. The plants grown out of the apogamic embryos are, to all intents and purposes, just as good as plants propagated vegetatively. If, therefore, it is possible to distinguish the sexual seedling from the apogamic one in the seed bed, nothing further will be needed to preserve a pure line of vegetatively produced stocks, beyond the elimination of the sexual seedling. The remaining seedlings may be show different sizes due to crowding and environment but would not be different genetically and should be expected to give more uniform performance as stock. Such a selection can be turned to good account by the nursery-men who will be able to obtain easily from any good stock type large batches of seedlings which can be depended upon to be a nearly uniform genetic type and to react uniformally on the scion.

If it is possible to use only those types for stock purposes, which show a greater percentage of apogamic seedlings, this along with the elimination of the sexual seedlings, will solve the problem of raising

citrus stocks vegetatively and will be more economical. It will enable the nursery-men to raise in one year from a single tree a very much greater number of vegetative progeny than would be possible by any other means of vegetative propagation.

In the case of mangoes the problem is more difficult. Poly-embryon is not common in the varieties grown in India to any extent. Production of uniform Root-Stock material is, therefore, very difficult. At the present time the best that can be done is to collect seeds from the trees of the same varieties and of similar performance and to carry out strict selection in the nursery bed so as to eliminate the varying types as far as possible. The other alternative seems to be to import varieties which are known to have Poly-embryon and to use them for stock purposes after careful selection of the seedlings.

Although it has not, so far, been possible to raise Root-Stocks of mangoes by some easy and simple method of vegetative propagation this possibility cannot be ruled out, and scientist should pay special attention to this aspect of mango stock problem. With the advance which has been made with the growth promoting substances it, should be within our reach to evolve a simple and economic way of producing mango stocks vegetatively.

SUBJECT NO. 2.

The standardisation of root stocks in relation to Soil, Climate, effect on Vegetative growth, bearing of Fruit Crops etc.

(Note by S. Bal Singh Bajwa).

Th interaction of stock and scion relationship is of great fundamental and practical importance in the cultivation of almost all important trees. Every Province, nay, even every important fruit growing tract of the same, because of the varied nature of soil and climatic factors, must determine by experiments suitable scion and stock combinations for its commercially grown fruit trees, in order to achieve the best results viz., high yield of good quality fruit over a fairly long span of life of the tree. Certain combinations prove very congenial and compatible, while others prove an utter failure, the former giving the best and satisfaction, while the latter resulting in ulter economic income ruin of the fruit grower. With a view to find out the best scion and stock combination for the commercially grown varieties of above fruits in the Punjab Province, the Punjab Government approached the Imperial Council of Agricultural Research, with a scheme to carry out Citrus stock trials in the year 1935. The scheme was approved in the year 1936 and it came into operation on 1st August in the same year Upto 31st July, 1941, this scheme was entirely financed by the Imperial Council of Agricultural Research but from 1st August 1941 one third of the recurring expenditure was met by the Punjab Government, while the remaining 2|3rd by the Imperial Council of Agricultural Research. From April, 1946 it was entirely taken over by the Punjab Government.

Four scion varieties viz. Malta Common (Citrus Sineensis), Malta Blood-red (Citrus Seneensis), Grape Fruit Marsh-seedless (Citrus Paradise) and Santra (Citrus Nobilis), were budded on the

following root stocks, which were propagated both from seeds and cuttings taken from the same parent tree:—

(1) "Kharna Khattas" (Citrus Karna. Raf.).

(2) "Mokeri" (Citrus Medica Linn).

(3) "Jatti Khatti" (Citrus Limonia Osbeck).

(4) "Mitha" (Citrus Aurantifolia Var. Swingle).

(5) "Nasnarian" (a citrus species obtained from Ceylon).

In addition "Jullunduri Khetti" (Citrus Limonia Osbeck) had been used only in case of Malta Blood Red and raized from cuttings and "Chakotra" (Citrus Decumana) only in case of Grape fruit Marsh Seedless and raised from seed.

The plant material thus raised was planted in an experimental orchard at Montgomery in the year 1936-37 according to the modern technique of laying out such experiments. Each experimental set of material was replicated six times, the number of plants in each scion stock combination being 18 to 24. Randomised Block method of Lay-out was employed and the distance between trees each way in rows was 20 feet. Points on which special study was made with regard to each scion and stock combination were (a) Growth and Vigour (b) Productivity (c) Fruit quality (d) Longevity (e) Resistance to diseases. The results, in brief so far obtained have been given below, which should be taken as tentative, though certain indications can be taken as final and which are unlined. These experiments must continue for at least two decades more to reach definite conclusions in all respects for making final recommendations.

(1) *Root-Stock influence on the Vigour of Trees*:—

The influence of root stocks on the vigour of the trees is indicated by the increase in stem girth, measured at a fixed point above the union of stock and scion. The trees of all the four scions on root-stocks raised for cuttings continue to remain large sized than those on root-stocks raised from seed. The following results hold good for root-stocks produced from seed and cuttings.

(a) In the prebearing age "Kharna Khatta" was leading all the stocks in its outstanding character of invigorating trees in the case of malta local, grapefruit and sangtra scions but due to increased cropping of Marsh Seedless grapefruit and malta local on trees budded on this stock the vigour of these scions on this stock is comparatively less in the bearing age with the result that in the year 1943-44, "Jatti Khatti" has actually come to lead the other root stocks, so far as vigour inducing character is concerned except in the case of Santra Local scion where "Kharna Khatta" is still maintaining its outstanding character of invigorating trees in the pre-bearing stage *"Kharna Khatta" has proved a complete failure with Bloodred scion and should not, therefore, be used for propagating this variety.*

The Bloodred malta trees budded on "Kharna Khatta" practically stopped their annual growth in the third year and 4 out of 18 plants even died in that year. In the fourth year the condition of

trees deteriorated still further so much so that these trees dropped most of their foliage in winter. In the year 1943-44 these trees in one by the two field of experiments, have proved to be significantly less vigorous than those on Mitha, which is a dwarfing stock.

(b) "Jatti Khatti" was next to "Kharna Khatta" for inducing vigour in the prebearing age. But in view of the increased cropping of trees of marsh grape fruit and Malta local scion varieties on "Kharna Khatta" "Jatti Khatti" has now come to lead all the stock excepting in the case of sangtra local scion. It is probably the best root-stock for malta Bloodred scion.

(c) "Mokari" and "Mitha" continue to dwarf all the four scions budded on them. Of these two, "Mokari" has decidedly a more dwarfing effect than "Mitha". The condition of trees of various scions on these two root stocks, excepting in case of sangtra local, is far from satisfactory. The size in each case is many times smaller than the size attained by trees of these scions on other rootstocks. There is lot of dying back of shoots and the trees in general present a scraggy look. *In view of this it can be safely asserted even at this stage that the further use of these root-stocks should be abandoned expect in the propagation of sangtra where conclusive results are not yet available.*

The Malta local and sangtra local trees on "Nasnorain" are in 1943-44 as vigorous as on "Jatti Khatti" and "Kharna Khatta".

(e) "Chakotra" which has been used as a root-stock in case of grapefruit scion only has produced trees of medium vigour.

(f) "Jullunduri Khatti" has been used only in case of Malta Bloodred and the trees on it are improving in vigour. It is now second best i.e. next to "Jatti Khatti".

2. The influence of root stock on the cropping of scions budded on them:—

(a) The trees of all the four scions on rootstocks raised from cuttings not only continue to remain large sized as compared to those on rootstocks raised from seed but the cropping in their case is also comparatively better.

(b) "Kharna Khatta" induced much better cropping in case of Marsh grapefruit and Malta local scions as compared with the remaining rootstock.

(c) "Jatti Khatti" outstandingly increased cropping only in case of Malta Bloodred.

(d) "Mitha" and "Mokari" both utterly failed in case of Malta local Malta Bloodred and Grapefruit.

Marsh seedless, the three scions under trial.

(e) "Nasnarain" induced nearly as heavy cropping as was done by "Kharna Khatta" in case of Malta local.

(f) "Chakotra" and "Jullundur Khatta" proved mediocre in case of Marsh grapefruit and Malta Bloodred scions respectively.

3. *Rootstock influence on fruit quality.*—The Physico-chemical analysis of the fruits of different scion varieties growing on different rootstocks were carried out during January and February each year. The results obtained are briefly reported as under:—

(a), *Size of Fruit.*—(1) "Mitha" and Mokari" both significantly increased the size of fruit in case of Marsh grapefruit, Malta local and Malta Bloodred varieties thereby deteriorating the marketting quality of fruit in each case. The remaining rootstocks behaved almost alike in influencing the fruit of the various scions under study but there are indications that "Chakotra" rootstock in case of Marsh grapefruit and "Jatti Khatti" in case of Malta scions might prove suitable for appreciably decreasing the size of fruit in due course.

(b) *Percentage of peel.*—"Mitha" and "Mokari" which, sufficiently increased the size of the fruit, also increased the percentage of peel in case of all the four scion varieties and of these two "Mokari" induced a higher percentage of peel than "Mitha". The remaining rootstocks may be taken, at this age of the trees, to have produced fruit with the least amount of peel although the indications are that "Jatti Khatti", "Kharna Khatta" and "Jullunduri Khatti" may prove better than others in case of Marsh grape fruit, Malta local and Malta Bloodred respectively. In the case of Sangtra the rootstock influence on the peel content of fruits in one of the two sets was not significant. In the second set "Mitha" and "Mokari" however, increased the peel content in the same way as in the case of grapefruit and malta scions.

(c). *The percentage of Juice.*—The Juice content was increased significantly by "Jatti Khatti", Kharna Khatta, and Chakotra root stocks in case of Marsh grapefruits, "Jatti Khatti" and "Kharna Khatta" rootstocks in case of Malta Local and Jullunduri Khatti "and Jatti Khatti" root stocks in case of Malta Bloodred as compared with "Malta and "Mokari" in which case the fruit was also invariably found partly dry inside. In case of Sangtra the influence of rootstock on the Juice content was not significant in one set whereas in the other set "Mitha" markedly increased the Juice content as compared to "Mokari" but its behaviour in comparison with the remaining rootstock is almost the same.

(d) *The percentage of soluble solids.*—The sugar content of fruit is considerably responsible for its quality. It was considerably increased by "Nasnarain" and "Kharna Khatta" in case of Malta local and Malta Bloodred scions respectively and by "Chakotra" and "Mitha" in case of marsh grapefruit. In case of Sangtra local scion "Mitha" increased the sugar content of fruit appreciably as compared with the remaining rootstocks, but the differences noted at this stage (at the age of even years) are not significant.

(e) *The percentage of Acidity.*—The light amount of acidity in the fruit of a given variety is as desirable as the adequate amount of sugar present therein. In fact it is the proper blend of sugar and acidity that determines quality. Generally speaking rootstocks that favourably influence the sugar content also increased the percentage of acidity. However higher sugar content increased by "Kharna Khatta" in case of

grapefruit was not followed by higher acidity, and higher acidity induced by "Mitha" in case of Malta Local and Malta Bloodred scions was not followed by higher sugar content in the case of these two scions.

General Conclusions regarding quality tests.—In view of the various standards of quality studied, it is obvious that "Mokari" and Mitha" as rootstocks failed badly in case of all the scion varieties excepting Sangtra local where their behaviour has not yet been fully determined. "Kharna Khatta" proved decidedly the best rootstock for Marsh grapefruit and Malta local scions, whereas "Jatti Khatti" and Jullunduri Khatti" have both done best in case of Malta Bloodred. There is a strong evidence that quality of fruit in case of Malta and Marsh grapefruit scions can be considerably improved by using "Nasnarain" and "Chakotra" as the rootstock.

General Conclusions.—Taking the combined influence of various rootstocks under trial regarding the vigour, cropping and quality of fruit of the four scions budded on them, it may be safely concluded that at this stage of the experiment, "Kharna Khatta" is decidedly the best rootstock for Marsh Seedless grapefruit and Malta local scions and "Jatti Khatti" and "Jullunduri Khatti" for Bloodred Malta scion. *"Kharna Khatta" is definitely a failure for Bloodred scion, it should not be used as a stock for this variety.*

The trees of all the four scions on rootstocks raised from cuttings not only continue to remain large sized as compared to those on rootstocks raised from seed but the cropping in their case is also comparatively better.

Economic aspect of the scheme.—It may interest the members of the Board, that whereas rootstock trials carried out at the Citrus stocks Experimental Station, Montgomery have given very useful indications and results, economic side of this station is equally remarkable. Generally, all over the world, Research Stations do not pay their way. But this Experimental Station has been unique in this respect. Since the trees came into bearing every year has been showing steady increase in income. Taking the instance of the year 1945, the total expenditure was about Rs. 12,000 (including even Pay and Travelling Allowance of the staff), while the income was about Rs. 25,000 leaving a net profit of Rs. 13,000. Considering the bearing area, which was only 10 acres, the average income comes to over Rs. 2,000 per acre. Considering the grape fruit alone, the auction price of 2½ acres was twelve thousand rupees *i.e.* Rs. 5,000 per acre.

APPENDIX—III.

Notes read at the meeting on subject No. 3.

By.—

1. Mr. G. S. Kulkarni.
2. Dr. R. S. Vasudeva and Raghubir Prasada.
3. Dr. K. C. Mehta.
4. Dr. B. B. Mundkur.
5. Dr. K. M. Thomas.
6. Mr. C. Vijayaraghavan.
7. Dr. B. P. Pal.
8. Mr. R. B. Ekbote.

CONTROL OF WHEAT RUSTS.

By G. S. Kulkarni (Mycologist, Gwalior Government).

Rusts which are locally known as *rori* or *Geruwa* are the most important disease of Wheat. Their ravages vary from year to year. In certain years when the attack is mild the loss may not exceed 5 per cent. of the crop. But in years when conditions for the development of the disease are favourable, (of repeated rainy and cloudy weather) the disease assumes epihytotic from and the damage is considerable involving complete distruction of the crop. The disease is, therefore, a constant menace taking a heavy toll of the wheat crop when it occurs as an epidemic and such occasions are of common occurrence once in every five years.

An average loss of 6 crores of rupees (according to Prof. Mehta of Agra) has been estimated for the whole of India for the wheat crop occupying an area of 3 crores of acres. Thus for every acre of wheat crop there is loss of Rs. 2. Calculating on this basis for the Gwalior State occupying 15 lakhs of acres of wheat the damage comes to 15×2= 30 lakhs of rupees. This is in normal years. But in years of heavy attack like the present one (1946-47) when the crop was completely destroyed the loss amounts to crores of rupees The economic importance of this disease is thus self-evident.

Considering the importance of the Rust disease the Indian Council of Agricultural Research constituted a scheme of investigation as early as 1925 (the work is still going on) and the results of investigation are as under:—

1. There are three kinds of Rusts that attack the Wheat crop. (*i*) Black rust (Puccinia graminis tritici). (*ii*) Yellow rust (Puccinia triticina). Each of these results has again got its (Puccinia glumarum), and (*iii*) Orange or Brown rust races. The black has nine forms, the yellow has ten and the brown has eight. There are thus 27 forms of rust that attack Wheat.

2. The yellow rust predominates in the whole of the Indogangetic plain comprising the Punjab., U.P. and Bihar. In peninsular area, *i.e.*, C.P. and Berar, Bombay, Nizam's Dominion and the Central India, the greatest part of Rajputana and Sind the Black rust is most destructive. The Brown rust is common everywhere.

3. Annual outbreaks of rust are not caused by the infection from the previous crop in the fields but are due to the source coming from the submountain parts of the Himalyas in the North and Ooty and Palni hills in the South, where owing to favourable conditions rust infection continues from year to year. The rust spores are blows from the hills to the plains by the wind. The hills thus serve the source of infection for the plains.

To prevent the annual outbreaks of rust infection in the plains would be to stop the infection from the hills reaching the plains. This could be done (*i*) by suspension of cultivation of Wheat for two to three years in the hills which occupy hardly 2 to 3 per cent. of the entire area under this crops in the country. But this method would be in impracticable without the co-operation of the concerned States that own a considerable part of the hilly tracts. Even with the co-operation of the States to execute the order would be very difficult as it would entail a large sum of money and staff. (*ii*) The other way of checking the spread of disease in the hills and thereby saving the crops in the plains would be to cultivate only rust resistant varieties in the hills.

The study of breeding rust resistant varieties for cultivation in hills has been in progress at the India Agricultural Research Institute, New Delhi, since 1935. The work is being done by the Imperial Economic Botanist, New Delhi, in collaboration with Prof. K. C. Mehta of Agra College.

None of the standard wheats of India have been found to be completely resistant to all the forms of the three rusts. It is difficult to say how long it would take to achieve success.

In the meanwhile the question arises what should Provinces and States having rust as pressing problem do? It may be noted that though the Indian Wheats have not been found to be completely resistant to rusts, the degree of resistance in them has been found to vary considerably.

The Wheats grown in India generally fall into two main groups (1) The durums (hard Kathia), and (2) the Vulgare (Pissi. soft). The durums such as, Bansi, Dautkhani, Kalabal, Jai, Vijay, Ekdania, G. D. 11, Jalalia, etc. are very susceptible to black rust. The Vulgar wheats like Pissi, Banda Sharbati, Pipandi White, most of I. P. Wheats, the Punjab ones (C 591. 118, 228) are less susceptible. Even among the Vulgar the hard amber coloured wheats are more tolerant to black rust than soft white-grained ones.

The varying factor of resistance is being utilised by various Provincial Governments to evolve varieties suitable to their respective localities. Such types when found out. would certainly be useful to mitigate the situation when cent per cent. destruction occurs in severe outbreak of rust attack.

With this object in view a scheme for the study of what is called "ADULT RESISTANCE" prepared in consultation with Prof. K.C. Mehta, Agra, was proposed by the Mycologist. The Durbar were graciously pleased to sanction it for three years (1942 to 1944) for Rs. 8,000. The experiment was carried out at the Gwalior and Ujjain centres and all the important samples of Wheat that are grown in the State were tested. The study did not show any variety of Wheat that could be considered as fairly resistant. In most of the types infection was more than 80 per cent. while the others succumbed completely. It was also considered necessary to try the varieties that were found to be resistant

in the Provinces. Accordingly samples were procured from the Agricultural Departments of the Punjab, Bombay, C.P., and Indian Agricultural Research Institute, New Delhi, and in 1945-46 new experiments were started at the Ujjain, Bhilsa and Gwalior Farms, on the varieties obtained from the abovementioned places, the local types serving as controls. In the first year no rust appeared in the crop. The trials were repeated in 1946-47. There being a severe outbreak of rust on the crop the results of the trials were found to be indicative. The Imperial Pusa Wheats with plump and glossy grains showed better resistance to the rust attack. Next came the Bombay Wheats which resisted the rust to some extent and produced well developed grains. The Punjab Wheats have been affected and, therefore, have shrivelled and shrunken grains. The C. P. Wheats (A.O.) have failed miserably while our local Wheats have hardly produced any grain. I.P. 111 has stood first in grain formation in all the three farms. The promising varieties (I.P. and Bombay) will be tested again in the coming season (1947-1948) to see whether they confirm their previous performances. A detailed list of the wheats used in the experiment showing yield per acre and weight of 1,000 grains, is attached for reference (see page 5.)

Our main Wheat-tract (Malwa) grows Durum (Hard) Wheats. The introduction of I.P. Wheats (Soft Pissi), (111, 80/5, etc.,) which are resistant to rust may be a temporary make-shift but may not be a final solution. We must try to breed our own Durum wheats suitable to the tract and having qualities with regard to yield and rust resistance.

The breeding of suitable varieties to each tract has been the main guiding factor in all the Provinces.

In the Punjab, breeding has been carried on for a very long time producing the noted types, C. 518, 591 and 228.

Bombay has produced Jai and Vijay and Niphad 4 which are high yielding and partially resistant to rust.

C.P. has its own A.O. wheats (68, 115, 13, 49, and 90) and is trying to evolve better types for rust resistance and yield. A special Research Station has been opened at Powarkheda, which is being subsidised by the I.C.A.R.

Pusa bred Wheats (now called I.P.—Wheats—Imperial Pusa) have been produced by the Imperial Economic Botanist suited for the Provinces of U. P. and Bihar.

A severe outbreak of rust disease in the Wheat crop occurred this year (1946-47) in the districts of Malwa Division. The intensity of attack was so severe as to destroy, in most of the places, 80 per cent. of the crop and even more in certain individual cases such as Bhilsa. The disease is known to have spread to most of the Central Indian States, the Central Provinces and Berar, Deccan Hyderabad, Khandesh and even as far down as Bombay-Karnatak. The wholesale destruction of the crop on such a vast scale especially at this critical period when the scarcity of food is so keenly felt is a cause for anxious consideration. The mycologist, therefore drew this fact to the attention of the Secretary, I.C.A.R., requesting him to place it before the Plant Patholog

Sub-committee of the Advisory Board meeting which met in New Delhi in February 1947. The Secretary was pleased to accept the suggestion and the subject was accordingly discussed by the Committee with a view to what measures, if any, were to be taken for the control and prevention of rusts. I.C.A.R. decided that each Province or State should be invited to submit schemes to I.C.A.R. for consideration. It may, therefore, recommended:—

1. The breeding of suitable (high yielding and rust resistant) varieties of wheat should be the main guiding factor for each province or State where rust is a pressing problem.
2. I.C.A.R. should prepare to consider schemes on the study of wheat rust submitted by the Province or State, for financial help.

With the above two points in view the paper has been submitted for the consideration of the meeting.

Comparative Statement of yield per acre and average weight of 1,000 grains (1946-47).

Variety of Wheat	Bhilsa Farm		Ujjain Farm		Remarks
	Yield per Acre. Mds. Srs.	Average weight of 1,000 grains (Grams)	Yield per Acre. Mds. Srs.	Average weight of 1,000 grains (Grams)	
I. P. III	7 30	43 0	7 2	35·20	
Niphad	9 0	41·4	4 1	26·10	
I. P. 165	8 0	38·7	4 0	24·70	
Jai	7 0	33·9	2 5	23·10	
I. P. 80/5	6 10	33·7	5 6	27·90	
I. P. 52	8 20	31·8	4 5	25·70	
Karnatac	7 0	33·7	1 2	16·27	
I. P. 125	7 0	31·5	4 0	24·70	
C. 228	6 0	27·1	5 1	26·50	
C. 591	6 0	26·6	2 6	15·90	
I. P. 021	7 20	26·4	4 2	20·40	
I. P. 101	8 0	25·2	4 0	16·70	
A. O. 68	6 0	24·3	1 7	12·50	
A. O. 115	5 20	22·5	1 8	15·80	
A. O. 13	6 0	22·4	1 4	11·20	
A. O. 49	4 10	21·1	1 6	11·70	
A. O. 90	4 30	18·4	4 5	19·10	
Local Pissi	3 0	16·1	0 7	14·50	
Local Kathia	0 10	15·8	1 6	23·03	

SUBJECT No. 3.

Cereal Rusts and their control.

by

R. S. Vasudeva, Ph.D. (Lond.), D.Sc. (Lond). D.I.C. Incharge of the Division.

and

Raghubir Prasada. M.Sc., D.Sc. Assistant Plant Pathologist. Division of Mycology and Plant Pathology, I.A.R.I.

Wheat, the most important food crop of the world, covers more than four hundred million acres of cultivated land. The major part of this area,—the vast wheat lands of Russia, Poland. Argentina, North America, India, China and Australia—suffers from the destructive ravages of rusts and their economic significance has been generally recognised by scientists and laymen everywhere.

In America, and Canada and other countries damage done by rusts has been carefully assessed. It was estimated to be 132,045,000 bushels in U.S.A. and 91.029,000 bushels in Canada in 1935. In the Indian Union the annual loss is calculated to be about Rs. 49,000,000.

Since the classical discovery of the heteroecism and the demonstration of the successive spore stages of *puccinia gramimis* by do Bary in 1864, much work has been done on the nature and prevention of cereal rusts in almost every wheat growing country of the world. In Sweden, Eriksson and Henning did extensive work culminating in the publication of "Die Getreideroste" in 1896.

During the last forty years American work on cereal rusts has dominated the scene. The occurrence of physiologic forms within *Puccinia graminis* was demonstrated by Stakman (1917) ; the ability of Thalictrum species to act alternate gosts of P. *triticina* was discovered by Jackson and Mains (1921) Craigie (1927) in Canada determined the function pycnia and stakman and his co-workers in U.S.A.. and Buller and Craigie in Canada studied the epiphytology of rust and their aerial migration. In 1935 Greaney started his experiments in Canada to determine losses caused by rusts and their control by sulphur dusting. On the basis of reactions on eight differential varieties Mains and Jackson distinguished 12 physiological races in P. *triticina* in 1926 and furnished a key for their identification. Newton and his associates demonstrated the formation of new races of P. graminis by hybridization on barberries.

In Australia, following the earlier work of Cobb, Mc Alpine and Prain, Waterhouse has made extensive studies on the over-summering of rust and their physiologic races and the breeding of resistant varieties.

In Russia the outstanding developments have been the discovery of *Isopyrum* as a functional alternate host of *P. triticina* in Siberia by Brizagalova in 1935. and extensive studies on the epiphytology and aerial migration of rusts by Shitikoya Rusakoya and others.

In Germany, Hungerford and Owens (1923) recorded the occurrence of "Specialized varieties" within *P. glumarum*, but the actual isolation of physiologic races was first done by Allison and Isenbeck (1930). Gassner and Straib (1930), however, standardised this work by selecting nine varieties of *Triticum vulgare* to serve as differential hosts.

In the Indian Union, wheat and barley are cultivated over 33 million acres of land. All the three rusts, *viz.*, black, yellow and brown, caused by *Puccinia graminis*, *P. glumarum* and *P. triticina* respectively, are relevant almost all over the country on wheat and cause enormous losses every year. Black and yellow rusts also affect barley.

There was such immense loss from wheat rusts in India in 1827 and 1839 that in some districts the harvest did not equal the seed that had been planted (Barclay 1892). It is well known that the yield and market value of grain is adversely affected as a result of rust epidemic. The cultivator is keen to know whether shrivelled grains raised from rusted crop can be used with confidence for securing normal yields. Tests recently made at the Indian Agricultural Research Institute with a large number of samples of shrivelled grains from rusted wheat crop from C.P., Rajputana and Bombay showed fairly good germination in most of the cases but it requires to be ascertained whether yield, from such crop would compare favourably with that obtained from crop raised from normal seed. Work on this important aspect is in progress.

According to Bolley (1906) and Ruskov (1925) light, small seed from rusted wheat crop produce plants of poor vitality and tillering which are likely to die if the soil is not well drained, heavy and cold or dry after germination. On the other hand Luthra and Chima (1942) state that the shrivelled grain obtained from crop affected by hot dry winds in the Punjab is suitable for seed purposes and that inspite of initial handicap the plants make up at a later stage and produce as good a crop as that obtained from normal plump grains.

Butler and Hayman (1906) and Butler (1918) were preplexed as to the origin of wheat rust infections following hot summers in the plains of India through which neither wheat nor its rusts can survive. Mehta as a result of his recent investigations explained that the uredinial stage of wheat rusts survives on volunteer wheat and barley plants in two hills at altitudes of 3,000—8,000 ft. infects the new crop locally and then the spores are blown down to the neighbouring foot hills and the plains causing fresh outbreaks. He has found two important foci, Central Nepal in the North, and Nilgiri and Palni hills in the south, where due to an early sown crop (August) and summer cultivation, respectively, there is plenty of inoculum available for dissemination at the time (October—November) when the new crop is sown in the neighbouring plains. In evidence of this he cites the presence of all the three rusts at different altitudes in the hills during summer on out-of-season self-sown plants and crop, early rust outbreaks in the hills and foothills, heavier rust infections at places situated at the foot hills than those farther of and late rust outbreaks at places remote from the hills. The practice of

raising wheat crop in summer (May-Nov.) in Mysore state and some parts of Peninsular India, according to him, is a dangerous practice as it serves to multiply the inoculum in close proximity of the crop that is sown in October-November, and thus brings about very early and severe rust epiphytotics on the latter. On the basis of the evidence produced by Mehta, the alternate hosts of black and brown rusts seem to play little part in the fresh outbreaks of these rusts in the plains of India every year.

Wild grasses have been found to act as collateral hosts of cereal rusts in some other countries like Canada, America, Australia and Europe. In India, Butler (1918) and Butler and Bisby (1931) recorded the occurrances of black rust on *Brachypodium sylvaticum*, *Festuca gigantea* and *Festuce Kashmiriana* in Himalayas but according to Mehta (1940) only the rust found on Bromus patulus and *Brachypodium sylvaticum* is the same as that on wheat. He, however, could not obtain any evidence to establish the propagation of this rust from one season to the next on any of these grasses. Recently, black rust has been collected on two more grasses, *Vilpia myuros* and *Briza minor*, in the Nilgiris. Information in this respect is far from complete and a thorough survey in this connection still requires to be carried out.

The study of physiologic races carried out by Mehta and his co-workers extending over a period of fifteen years has resulted in the identification of eight races of black rust, ten of yellow and eight brown, some of which have not been reported outside India. It is, however, necessary to greatly extend this aspect of the investigation so as to pick up other races that might be present.

Control.—The relative merits of different methods of control as applicable to Indian conditions are discussed below :—

1. The eradication of alternate and collateral hosts.
2. Destruction of "self-sown" wheats and suspension of "out of-season" wheat cutlivation.
3. Use of fungicides and other chemicals.
4. Fertilisers and cultural practices.
5. Breeding of resistant varieties.

1. *Eradication of alternate and collateral hosts.*—In those countries where *Barberries* acts as an alternate host, its eradication has been enforced in order to achieve the control of black rust. With this end in view in 1918 United States Department of Agriculture in cooperation with other states started a berberry eradication compaign. Destruction of more than 323 million barberry bushes on 130 thousand properties in 18 states has been accomplished and this has contributed considerably to the reduction in the stemrust losses.

According to Mehta, in India like Australia barberries seem to play little part in the annual recurrence of black rust. The eradication of barberries, therefore, is not called for in this country. However, in view of the fact, that new races are formed on barberries, it is very

necessary to undertake a thorough survey of naturally infected barberries in the hills of India.

With regard to brown rust, Jackson and Mains (1921) were able to infect *Thalictrum* but no where has it been found to occur naturally infected and is not considered a functional alternate host. No species of *Isopyrum*, reported to be the alternate host of *P. triticina* in Siberia, occur in India.
No alternate host of yellow rust has been discovered so far.

Wild grasses have been reported to act as collateral hosts of cereal rusts but information for this country is very meagre and further work in this direction is necessay.

2. *Destruction of "volunteer" wheats and suspension of "Out-of-season" wheat cultivation.*—Mehta, from his extensive study of wheat rusts in India, recommends the destruction of self-sown wheat and barley plants in all the hills, and hilly tracts where these rusts have been found to over summer, and the suspension of "out-of-season" wheat cultivation in the Nilgiri and Palni hills, the peninsular India and Central Nepal. The Mycologists in this country have expressed serious doubts as to the efficiency of this method of control and the practicability of its rigorous application, particularly when there are indications that certain grasses are also effected by the rust. Stakman, Popham and Cassell (1940) found a similar situation in Mexico and Southern U.S. They came to the conclusion that " the rust in northern Mexico, Taxes and adjacent states constitutes a menace for the wheat farther north because the distance to which spores can be carried is almost unlimited and recommended that "stem rust probably could be controlled to a considerable extent in southern Mexico by eliminating the relatively small amount of summer wheat and the prematurely sown fields of winter wheat in order to avoid the overlap of wheat crop seasons". The recommendations, it appears, have not been given effect to and it is therefore difficult to assess their merits.

3. *Use of Fungicides.*—Between 1891 and 1894 Cobb in Australia, Hitchook and Carlton in the United States and Wuthrich in Germany tested a number of chemicals for their efficiency in preventing the germination of uredospores. Copper, mercury, and zinc salts even in high dilutions were found effective.

The efficacy of sulphur in preventing the germination of uredospores was shown by Greanery in Canada in 1228 and 1934. Kolodust was found to be the most effective, probably because of its fineness. In field trials he noticed an increase yield ranging from 5 to 15 and in some instances 20 to 30 bushels per acre as a result of 9 applications of 15 lbs. of sulphur each. Mains (1930) in Indiana, Broadfoot (1931) in Minnesota and Bolley and Pritchard (1906) in North Dakota obtained higher yields by frequent sulphur dusting. On account of the prohibitive cost of dusting sulphur over large areas Greanery recommends it only "for the use of experimentalists, seed growers, and grain exhibitors". The effect of sulphur is purely prophylactic. It can prevent spore germination or destroy the germ tubes, but once infection has been accomplished

the rust mycelium appears to be relatively unaffected by sulphur on the leaf surface. All the evidence available indicates that sulphur does not exert any direct effect on the soil or the wheat plant so as to affect the outturn, (Greaney, 1941). Likewise Phipps (1938), Butler (1940) and Broadfoot (1931) found that sulphur had no effect on yields of rust-resistant varieties. Under Indian conditions no work has so far been done to determine the economics of sulphur dusting as a method of rust control. Apart from the use of sulphur, Sibilia (1937) increased the yield of wheat by 4 applications of "Asporitol" but he did not consider dusting practical unless rust was heavy. In 1941, Straib sprayed greenhouse plants, at varying times after inoculation, with a number of organic substances and got absolute control by 1 per cent. paratoeuol sulphonamide if applied immediately after rust inoculation, but applications 2-4 days after inoculation were less successful.

Shitikova-Roussakova (1937) used 5 per cent. sodium silicofloride, 93 per cent. fine clay and 3 per cent. lubricating oil which was found to equal sulphur in rust control. None of these treatments has, however, found to be applicable to large areas or economically feasible.

4. *Fertilisers and cultural practices.*—Work done outside India has indicated that, in general, nitrogenous fertilizers tend to increase susceptibility of the wheat plant, while phosphate has the opposite effect. It is now generally accepted that rust may be reduced in severity by reducing the proportion of N. in the N.P. ratio.

Cultural practices which favour early maturity of the wheat crop, lessen the destructiveness of rusts, as they enable the crop to escape the most serious effects of the disease. This can, however, have only limited application. Early maturation may expose the plants to frost at the time of flowering and thus lead to sterility or the yield may be reduced as a result of a shorter growing season.

5. *Breeding of resistant varieties.*—Chester (1946) states that the breeding of cereal varieties that are resistant to rust is the most certain, effective and economical means of checking the cereal rusts. In 1886 Farrer in Australia, began the extensive and intensive breeding and selection for rust resistance in wheat and was so successful that some of his hybrids, *e.g.*, Federation, are of agricultural significance even today.

Hitchcock and Carleton in 1894 had also recognised that the breeding of "rust-proof" wheats offered the most promising means of rust control. Biffen, in England, applied the principles of Mendilism to the breeding of wheats for resistance to yellow rust. In the United States of America and Canda intensive work has been done for breeding varieties for resistance to black and brown rusts. In Australia, Waterhouse has been particularly responsible for the breeding progress resulting in the release of "Febweb I" and "Gabo".

In Russia here has been a well organised and highly successful programme of wheat breeding and particular attention has been given to the use of interspecific or even intergeneric crosses resulting in the production of the remarkable *Triticum sovieticum.*

The breeding of rust resistant wheats has been found to be difficult and slow; one of the reasons for this, in earlier works, was the lack of knowledge of the existence of physiologic races in the rusts. In the year 1917, Stakman and Piemeisel demonstrated the existance of physiologic races in *Puccinia graminis tritici*, which are morphologically similar but differ in their pathogenicity to different varieties of wheat. With this knowledge the reason for the sudden breakdown of resistant wheat varieties became clear.

Nearly 200 races of black rust are now known, and similarly races exist in the brown and yellow rust, also new races may arise by hybridzation or mutation. While the existence of these numerous races renders the task of breeding an arduous one, encouraging features also occur, Many workers have observed that wheats that are susceptible as seedlings may become resistant as they grow older and that resistance to a number of races may be governed by a single factor.

In India, the work of breeding resistant varieties based on the knowledge of physiologic races in only of a recent origin. It was started 2 years back based on the number of physiologic races found by Mehta. At Simla high resistance to all the physiologic races has been achieved separately for each rust, and the work is at a stage when synthesis of resistance to all the three rusts simultaneously is being attempted by means of a double cross made on a large scale. In the Central Provinces and Bombay, the work is concerned with resistance to black rust only which is the dominant race in those Provinces. In view of the importance of this work, it needs to be greatly extended.

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Subject No. 3

CEREAL RUST AND THEIR CONTROL.

(Note by, Dr. K. C. Mehta.)

(1) The universally recognised long-term method of rust control is the cultivation of rust resistant varieties. Work on the breeding of rust resistant varieties for cultivation in the hills, *i.e.*, the source, has been in progress since the year 1935 at Simla as co-operative investigations between the writer and the Head of the Division of Botany, Indian Agricultural Research Institute.

(2). As rust resistant varieties are not yet available, and it might take several years more to produce them, it is very desirable that efforts be made to mitigate the huge loss caused by rusts by the adoption of a short term plan of control. This can be done by (i) Regulation, *i.e.*, suspension under legislation of sowings of wheat and barley during summer (April to September) wherever made in the whole of Peninsular India (hills and plains) and (ii) by the cultivation of improved varieties of oats, fit for human consumption, and rye in places of wheat and barley in the Himalayan range as well as the hills in the Central parts of the country. Oats are not affected by any of the three rusts of wheat and some of the varieties of rye are resistant to black rust of wheat ; the other two rusts do not affect rye.

(3) Simultaneously with nos. (1) and (2) it would be useful to test the efficacy of sulphur dusting mixed cropping and the effect of different kinds of manure on the incidence and in tensity of rusts.

K. C. MEHTA,—23-2-48.

Subject No. 3

CEREAL RUSTS AND THEIR CONTROL.

(Note by Dr. B. B. Mundkur).

While breeding of rust resistant varieties of wheat is the more certain method of controlling the disease, the difficulties involved in that process have to be carefully analysed and understood. There is not one rust affeding wheat but there are actually three. Each rust is segregated into several physiological races, there being eight or more of each in India alone. Breeding of variety of wheat resistant to all these three rusts and to each and every one of the races present in a country will be a stupendus and colossal task and I doubt if it would ever be possible to do so. Breeders in Canada, U.S.A., Germany, Australia and other countries have yet to obtain a wheat resistant even to a single rust, and to each and every one of the races of that rust occurring in their respective countries. When such varieties were obtained or were about to be obtained, the appearance of a new race by mutation, hybridization or importation has upset all calculations. The fate of Kanred, Hope, Webster, Thatcher and other resistant wheats are cases in point.

It is necessary, therefore, to take a realistic view of the problem. I have, of course, no easy solution to offer but the lesson of the 1946-47 epidemic has left the impression that, if nothing else, at least the seed supply of a district or a province must be ensured. In the C.P. for example, the epidemic was so severe that wheat was scarce and it was not available even for seed purposes. I believe 40,000 tons of seed had to be secured from outside. The importing of that seed, its storage, its germination tests etc. involved much labour and sometimes it was not certain whether imported seed would suit the C.P. conditions though reports indicate that it had done well.

In order then to ensure at least the seed supply, I would urge that in provinces where periodic rusts epiphytotics are apprehended, there must be in reserve at least 20 tons of sulphur dust and not less than 200 hand dusting machines of the crank type so that operations can be started as soon as signs of danger are indicated. These signs are unusual and heavy rains in Peninsular India in November and early part of December associated with cool temperature.

The sulphur would not necessarily be used every year but would be reserved for use only in such emergencies. The sulphur reserves and the dusting equipment would naturally be stored in an area where best wheat cultivation of superior varieties is concentrated in a province. I think that four or five dustings would suffice though future experience along would give more precise information. But whatever the cost, the saving of the crop for seed purposes alone is worth all that expense.

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Subject No. 3

CEREAL RUSTS OF SOUTH INDIA.

The rust which infect cereals in India are among the most important of the rusts from the farmer's standpoint. This is due to the fact that these fungi affect the main food crops and the amount of destruction caused is on an extensive scale. Rusts do not appear with the same intensity year after year ; but depending on various enviroumental and other factors the incidence may be inconspicuous or may assume an epiphytotic form as was experienced during the last season in India. It is common to speak of certain years as "rust year". The rusts are of world-wide occurrence and considerable losses have been caused in most of the wheat growing countries some time or other. In other countries strenuous efforts are being continuously taken to control the rusts. In India the recent experience of the devastating epiphytotic was in 1946-47. Attempts have been made on a small scale to evolve rust-resistant strains of wheat in certain parts of the Dominion.

There are six important rusts of cereals in the Madras Province and these are found on wheat, barley, oats, sorghum, cumbu and tenai. These shall be considered one after another.

Wheat (*Triticum* spp.).—There are three rusts, the stem rust or black rust (*Puccinia graminis*) the stripe rust or yellow rust (*P. glumarum*) and leaf rust or brown rust (*P. triticina*). The wheat crop is grown on an area of 12,300 acres of which nearly 2,500 acres are on the Nilgiris and Palnis. Small areas are grown to wheat in the districts of Coimbatore, Salem, Guntur, Kurnool, Bellary and Anantapur which constitute the wheat growing areas of the province.

All the three kinds of rusts are prevalent on the Nilgiris and Palnis. In the plains, however, yellow rust is not noticed. Of the three rusts the stem rust is considered to be the most destructive. It occurs on wheat, barley and oats. But the rust occurring on oats is different from those on the other two hosts in its host range. A very large number of biologic forms have been recognized in *P. graminis tritici* (the wheat race). Of these, five forms have been determined from South India. Besides the hosts mentioned above this rust has been found on two common grass hosts on the Nilgiris, viz., *Vulpia myuros* and *Briza minor*. The particular form found on these hosts has not been definitely determined.

Next in importance is the leaf rust of wheat which has been recorded from all over the province. Very often the damage caused by this rust has been under-estimated. In certain years it has been known to cause by itself considerable loss due to a reduction in the number and size of grains formed. In this rust also a number of biologic forms have been recognized.

Yellow rusts affects wheat and barley. But it is confined in its distribution to Nilgiris and Palnis and does not occur in the plains. Under local conditions the damage caused by this rust is not much though in some foreign countries like England and Germany it is considered to be the most serious of the rusts on wheat. Several races have been distinguished in this specis also.

Sorghum (*Sorghum vulgare*).—This is grown over 4,800,000 acres in this province. It is infected by a leaf rust *Puccinia purpurea* which produces reddish or purplish pustules on the leaf. The loss caused by this rust has not been correctly estimated. According to one view it is said to cause appreciable reduction in yield of grain while according to others the loss caused is very little as the rust appears late in the life of the plant and is confined to the older leaves. The truth may be between these two extremes and as in the case of wheat rusts depends on various factors. This rust has received very little attention in India. It is known to occur on cultivated sorghums, *S. halepense and S. sudanense* and is prevalent all over the world in the sub-tropical regions.

Cumbu—Bajra (*Pennisetum typhoides*).—The area under this crop is 2½ million acres. There is a common rust *Puccinia penniseti* throughout this province causing the formation of enormous number of pustules on the leaves. As in the previous crop no correct estimate of the loss caused by this rust is available but in some years the severity of infection is bound to reduce grain setting.

Korra or *Tenai* (*Setaria italica*).—The cereal is grown over an area of one and half million acres. It is subejct to a rust *Uromyces setariae italicae* found all over the province. In some years the incidence is low. But in other (as in 1944-45) in the Ceded districts, it causes complete destruction of the crop. The potential danger from this disease was recognized only then. For, even Butler states that "it is probable that this rust causes little damage partly because it appears late at about the ripening period of the host plant". It emphasizes the fact that rusts which are obligate parasites are always a source of potential danger though they may appear to be harmless under certain conditions.

Survival.—The rusts enumerated above produce two kinds of spores on the cereal host plan—the uredo and the telento spores. The complete life history or the alternative hosts for these, if any, have not been followed in this province. The first of the two kinds of spores formed on the cereal host is really the important phase for the continuance of the rust from one season to another as the other spore does not infect the cereal host. The investigation on the viability of the spores under different climatic conditions prevalent in the country is not complete for all the cereal rusts. The uredo spores of wheat rusts are said to be killed by exposure to the high temperatures prevailing in summer on the plains of India. Dr. K. C. Mehta has put forward a theory that the uredo spores of wheat rust over summer only in the hills of Nilgiris, Palnis. Central Provinces and foot-hills of the Himalayas and spread to the plains of India from these areas. More data and further critical investigations are necessary before this can be completely accepted.

In the case of cereals like sorghum, *Pennisetum typhoides* and *Setaria italica* the information available about the viability of the uredo spores and method of survival is scanty and more often speculative.

Control.—Rusts are not easily amenable to direct control by the use of fungicides. Though attempts have been made in foreign countries to dust the wheat crop with sulphur from aeroplanes to control the rust, the amount of success achieved and the cost involved do not warrant the adoption of such methods in this country.

The more rational and practical method of control is by breeding resistant varieties of cereals. This is the method being exploited in other countries also. But it has to be borne in mind that numerous forms exist in the rusts and to evolve a strain with desirable qualities and resistance to all these forms is a hard and tough job. Further, it is an eternal struggle as both the parasite and the host are living organisms capable of variation and change, so that continuous efforts have to be maintained. Breeding stations have to be organised in different parts of the province to tackle different crops. Fortunately a number of varieties exist in each crop which exhibit different degrees of susceptibility to the rusts. For example, the alocal samba wheat on the Nilgiris is resistant to black rust susceptible to brown and yellow rusts. Similarly among *Setaria italica*, sorghum and *Pennisetum typhoides* different strains exhibit differences in susceptibility according to field observation.

These field observations alone will not suffice. Actual study of the parasite, its forms, the conditions for infection and the intrinsic resistance of strains of crops by actual infection experiments under optimum conditions are necessary to enable breeding of resistant varieties.

The pathologist must certify to the desirability of a strain being multiplied. For this purpose the active co-operation of the plant-pathologist and the breeder are necessary. Releasing strains for multiplication without passing them through infection tests will be waste of time and energy. New strains of crops spread without previous resistence-tests will upset the equilibrium of host-parasite relationship established in the tract and lead to serious epiphytotics.

The necessity for a wheat breeding station on the Nilgiris has been recognized and proposals have been submitted for starting one for breeding resistant wheat. Similar works essential with regard to the other cereals also. For this puropse a cereal rust investigation officer has to be stationed in the province with laboratories in Nilgiris, Coimbatore and Ceded districts for sustained research on the resistance trials of the different crops. His services must be utilized by the crop breeder to test the new strains developed before distribution to districts.

AGRICULTURAL DEPARTMENT,
MADRAS.
15th December 1947.

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[*For Official use only*]

Subject No. 3

CEREAL RUSTS WITH SPECIAL REFERENCE TO THOSE OF *SETARIA ITALICA* AND THEIR CONTROL.

The rust of cereals are a serious menace to the economic production of grain crops. Their destructive capabilities have attracted the attention of scientific workers in all cereal growing regions of the world and provided an impetus to the advancement of our knowledge regarding the parasites responsible for the disease and their relationship with the hosts. The greater part of the progress made in the direction of studies on rusts has been concerning cereal rusts, especially wheat rusts, which in all wheat-growing countries, under favourable conditions, more or less totally destroy the crop and prove to be an insurmountable bar to economic production. In India all the wheat rusts, viz., black, brown and yellow caused by *Puccinia graminis tritici* Eriks, and Henn., *P. triticina Eriks* and *P. glumarum (Schm)* Eriks and Henn., ravage the wheat crop.

An estimate made about 40 years ago fixed the annual loss from this cause to be not less than Rs. 40,000,000. The recent researches of Mehta have contributed greatly to our knowledge of rusts in India and he considers the loss to be about Rs. 60,000,000 from the crops wheat and barley. This will point out clearly the importance of the rust problem

in this country. Rusts on smaller grains have not attained the same importance as those of other cereals due to the minor role of those crops in contributing to the supply of the country and also to lesser virulence of the disease.

The rusts have a varied range of hosts and many of the forms are very important being highly parasitic on economic plants. Advance made in the knowledge about the etiology, epidemiology and methods of control is great, but a detailed review of the work done is not attempted in this short note. The methods of control suggested in various places as a result of thorough studies on the life histories and epidemiology of rusts are different. The discovery that wheat rust has its aecidial stage on the barberry stimulated the destruction of these alternate hosts with a view to control disease, and in U.S.A. enormous efforts have been made in this direction. In Australia, barberry is uncommon, yet the incidence of rust in epidemic form has been experienced and evidence points to persistence of these rusts from year to year in the uredospore stage on volunteer plants and grasses growing in favourable localities.

Mehta (17) after an intensive study of the cereal rust problem in India advocated the destruction, 1 to 2 months before sowing, of all "out of season" wheat and barley which carry over the rusts in all hills and hilly tracts, suspension of cultivation of wheat and barley for a period of two or three years, in the hills, and also postponement of sowing to October as possible methods of control of rust epidemics in Peninsular India and Indo-Gangetic Plain. But there are practical difficulties in implementing these suggestions due to the huge financial loss involved, and they have not found favour with the growers. Application of fungicides like sulphur has been reported to be effective to some extent in checking the disease, but it has not been found to be applicable to large areas or economically practicable or acceptable to the farmers. The possibility of breeding plants resistant to disease as a successful solution of the problem was not well realized until Biffen in the early years of this century demonstrated the resistance to rust in wheat as a recessive character transmitted in the simple mendelian way. Thereon research on various aspects of disease-resistance in plants has been made, and with the knowledge gained thus, it has become possible to synthesize varieties of plants which can successfully withstand disease. This method of disease control has become particularly true of rusts, where ordinary mechanical and chemical methods have not taken us far, due to the complexity of problems involved in epidemics (22). Breeding resistant varieties of plants offers the best and cheapest method of disease control because of the greater efficiency and the reduction of labour and extra expenditure to the cultivator.

Many authors have contributed to our present knowledge about the inheritance of disease resistance in plants especially in the case of wheat rusts. Biffen (2,3,4) and Nilson. Ehle (18) observed susceptibility to *Puccinia blumarum* to be dominant in different forms of wheat and that in the F generation there was transgressive segregation for resistance and susceptibility. Similar results have been obtained by Pole Evans

(19), Hayes, Parker and Kurtzil (12), Melchers and Parker (19). Stakman (22) showed that various physiologic forms of the parasite exist and are again produced by mutation and hybridization (1). This further increased the complexity of the problem of breeding for resistance but fortunately it has been found out by Goulden, Neatby and Welsh (10). Harrington and Smith (11), Neatby (19), Reed (22), Welsh (26) and Briggs (5), that reaction to each individual physiologic form is governed by an independently inherited element of the genotype, and hence the production of a variety resistant to the different physiologic forms does not involve the combination of resistance to individual forms from different types but to a group of forms governed by single genetic factor or such factors which are so linked that they act as individual elements.

That the reactions of the adult plant in the field and those of the seedling in green house are inherited independently, and that homozygous lines could be evolved by combining seedling immunity and field resistance to rust in wheat was shown by Hayes, Stakman and Aamodt (13), Goulden (9) and Clark and Ausemius (8). With the help of the knowledge gained in these studies great achievements have been made in breeding plants resistant to the disease (15, 16, 17).

Generally breeding is resorted to, in combating disease, only in cases where other methods have failed and where disease assumes serious proportions and cause considerable loss. The evolution of a variety resistant to disease, though a process involving much labour and expenditure in the initial stages, is about the best solution in the long run and the production of types combining disease resistance and desirable agronomic characters in the various cultivated plants should be one of the main lines along which work has to be carried out. It will be seen that the large bulk of the work done on this problem pertained to wheat. Studies on resistance to disease in other cereal crops are very meagre. In India millets occupy the next important place as food crops after rice, and most of these come within the host ranges of rusts. Though relevant data on the loss due to this disease on the millets are not available, rust has been found to be a serious disease in the case of some of these. Among the millets, *Tenai* (*Setaria italica*) is the most susceptible to this disease, and attempts made in this direction of evolving varieties of *Tenai* resistant to rust (*Uromyces setariae italicae*) in Madras Presidency are presented below.

The Italian millets (*Tenai*) is an important crop in the Madras Presidency occupying about 4.6 per cent. of the total area sown to crops. The total normal area under this crop is more than 1.5 million acres. *Tenai* is generally consumed by the cultivating class only. Though it is poor man's food, in times of scarcity it serves as a good famine reserve and takes the place of other more important foodgrains. Rust epidemics on this crop are common in the Ceded districts where it is mainly grown.

The parasite causing the disease is *Uromyces setariae italica* (*Diet*) Yoshino. This has been reported from all important *Tenai* growing regions. Hemmi (14) reports the wide distribution of this rust over the main island of Japan. Butler (7) has given an account of the biology

and life history of the parasite as observed in India. Brown (6) recorded the existence of heterothallism in the fungus. But evidence is lacking on various other aspects of the fungus in causing damage to the crop. The meagre knowledge concerning the life history of the parasite and the epidemiology of the disease proves to be a great obstacle in devising measures of controlling disease. But as in other crops, the breeding of resistant strains seems to be the most promising line. and the preliminary results achieved are very encouraging.

Experimental methods and materials.—With the object of isolating a strain of *Tenai* resistant to rust a large collection of seed from the important *Tenai* growing areas was made at the outset and these were put to test in the field. Three stations situated in representative centres, viz., Hagari, Coimbatore and Ootacamund were chosen as venue for the trials, as these places offered the representative climatic conditions.

The experiments were laid out on lattice designs, with four replications for the preliminary trials, and the selections advanced from these trials were put in comparative trials in randomized blocks, with standard strains as controls.

In the first year of the trial, the inability to culture the fungs *in vitro* necessitated the natural infection of the crop to be taken recourse to but in the subsequent trials, the diseased plant material collected from preceding trials, and crops of *Tenai* grown at intervals of 1 to 2 months to carry over the disease, supplied the inoculum. Inoculations were given three weeks after sowing by spraying the spore suspension on plants under trials. In order to ensure infection and also to serve as a source of inoculum by creating an artificial epidemic, highly susceptible types viz., S. I. 3396 and S.I. 3560 were sown in between the rows of the types on the incidence of disease in each type and yield were recorder and under test and also as belts around the blocks. Before harvest, data they were statistically analysed.

Experimental results.—In 1944, the first year of the trials, 91 single plant selections from the cultivated fields in Bellary and Anantapur and five from Agricultural Research Station. Guntur, were tested with H.K. 23 and H.K. 68 as standard at Hagari. Rust infection was not serious enough to damage the crop, but no plant was completely free from disease But in 17 of the new selections and also H.K. 68, the incidence of disease was less than in others. The 68 types studied at Coimbatore in the same year showed varying degrees of susceptibility, and 11 types which showed minimum infection were selected for further study.

These 29 selections which showed less incidence of disease and 32 new ones were grown under irrigation at Coimbatore in the summer season of 1945. In seven of these selections the average rustiness was less than six. Among these, four viz., S.I. 3670, S.I. 3779, S.I. 3782 and S.I. 3756 were significantly superior of the standard S.I. 523 in yield in previous comparative trials. Studies made at Ootacamund an

the same season with twenty varieties, showed the following ranges of rust infection :—

Percentage of infection. Per cent.	Type.
100	S.I. 544, S.I. 352 and S.I. 2970.
65	S.I. 2667, S.I. 3781, S.I. 3782, H.K. 68 and H.K. 261.
40	S.I. 3670, S.I. 3779.
25	S.I. 523, S.I. 3223.
10	S.I. 2980, H.K. 207, H.K. 218.
5	S.I. 2470 and S.I. 3677.

This work was continued further and the 8 selections chosen for their high resistance and 64 new types were tested in the monsoon season of 1945. But the differences in rust resistance were not significant.

In the succeeding summer season the 7 selections which had greater resistance than the rest and 15 selections obtained from Hagari were put for trial. One of the seven selections S.I. 4054 was significantly superior to the rest in resistance. From the 15 new selections tested, 11 were taken for further trial.

The third trial of the seven highly resistant selections of the previous experiments was conducted in the north-east monsoon season of 1946. Observations made indicated that S.I. 4054 was the least affected by the disease, and in yield of grain it was second only to S.I. 3670. In the same season another trial was conducted under the same conditions with eight new selections, H-2 being the standard. In this test, S.I. 4190 was the least susceptible and the highest in yield.

The selections tested in 1946 were again put under trial in the summer season of 1947 as an irrigated crop. The incidence of disease was only mild at the time of ripening. The results showed that S.I. 4054, S.I. 3756 and S.I. 3779 were the least affected and that S.I. 4054 was significantly superior to the rest in grain yield, were the least susceptible and S.I. 4316 was significantly superior to the rest in yield

Conclusions.—As a result of these trials, the degree of variability in susceptibility to rust of different strains of *Setaria italica* have been clearly observed. It has also been possible to isolate a few strains—one of which S.I. 4054 is highly resistant to the disease and a good yielder too. Futher work is in progress at the Millet Breeding Station, Coimbatore, and other centres to evolve strains which combine high yield and resistance to rust, by selection and hybridization. The genetic aspect of assistance to rust in the Italian millet is also under pursuit.

Lacunae in the present knowledge about the physiology and life history of the parasite serve as drawbacks in the production of inoculum and artificial epidemics to study the resistance of varieties. Hence further research on these aspects of the disease is absolutely necessary in devising methods of control.

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AGRICULTURAL DEPARTMENT,
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Subject No. 3

THE CONTROL OF WHEAT RUSTS BY BREEDING BY B. P. PAL, HEAD OF THE DIVISION OF BOTANY, I.A.R.I.

Introduction.

The importance of breeding resistant varieties as a method of wheat rust control is now well recognised and Chester (1946) in his comperehensive book on cereal rusts affirms that "The breeding of cereal varieties that are resistant to rust is at once the most certain and effective, and the most economical means of checking he ravages of the cereal rusts".

Breeding of wheat for rust resistance may be said to have originated with the pioneer work of Farrer at the close of the last century ; this work was so encouraging that rust resistance as a measure of rust control was well established in Australia. In the early years of this country, Biffen at Cambridge applied the newly re-discovered Mendelian principles of heredity to breeding wheat resistant to yellow rust. This was followed by very intensive work in other countries, especially in the United States of America and Canada.

The subject of wheat rust control by breeding and the progress achieved have been competently reviewed several times in recent years (Waterhouse 1938, Wingard 1941. Neatby 1942, Ausemus 1943, Chester 1946, Dastur and Pal 1947) and it is therefore not necessary to give a detailed review of the progress here.

It is now well known that the three rusts attacking wheat, (black or stem rust caused by *Puccinia graminis tritici Eriks,* and Henn brown or leaf rust caused by *Puccinia triticinia Eriks* and yellow or stripe rust caused by *puccinia glumarum* (Schm.) Eriks have differing temperature requirements; thus yellow rust develops best in comparatively cool weather while brown rust is adapted to slightly higher temperature and black rust is favoured by still higher temperature and black rust is favoured with some lower temperature ; adaptations to light and moisture also no doubt exist but are less obvious. The distribution of the three rusts deflects their varying requirements, especially in respect of temperature.

A very considerable amount of knowledge has been built up regarding the three wheat rusts, their life histories, genetics, etc., and also regarding the susceptibility or resistance of a large number of varieties of bread wheat and of allied species and genera. The more important facts and findings which are relevant to the present discussion will be referred to in the paragraphs that follow.

The nature of rust resistance in wheat.

When it was established by Biffen (1905) that resistance to yellow rust was inherited on a Mendelian basis, it was anticipated that breeding for disease resistance in general and for rust resistance in particular would make rapid strides and that the knowledge now available regarding the genetic basis of plant characters would enable breeders to realize completely their ideal of varieties uniting high yield, good quality

of grain and a high degree of disease resistance. Although some successes were achieved the general experience as regards breeding for rust resistance was that the problem was more complex than it seemed to be in the beginning. Thus it was disconcerting to find certain varieties believed to be resistant behaving erratically from year to year, and different localities. The reason for such behaviour are now much completely understood. Amongst the important additions to knowledge of the subject in the present century are :

(1) The demonstration by Stakman and Piemeisal in 1917 that physiologic races existed in the black rust fungus *Puccinia graminis tritici*, which were morphologically indistinguishable from each other but which varied in their ability to attack different varieties of wheat. At least 200 physiologic races of black rust are now known (Johnson and Newton 1946). Fortunately all these do not occur in any one country and all the 200 do not occur in nature, some having been produced in experimental hybridization studies. What has just been stated appears to hold true generally for the two other wheat rusts also. At least 129 distinct races of brown rust have been reported (Johnson and Newton 1946 ; 47 races of yellow rust had been identified by 1939 in Europe by Straib (cited by Johnson and Newton *loc. cit*) exclusive of several races described by others.

(2) The demonstration that fluctuations occur in the relative abundance of particular races of black rust from year to year (Levine 1928, Newton 1938, Stakman etal 1943 etc.,). Johnson and Newton point out (1946) that "the question of whether the predominant races of a region give way to other races is of particular interest to investigations concerned with the development of new varieties because any such radical change is equivalent to a change in the pathogenicity of the rust".

The distribution of the races also varies in the different wheat growing regions of the world and there are rather pronounced pathogenic differences between those occurring in widely separated regions (Johnson and Newton 1946).

According to Johnson and Newton (1946) there is no evidence of any great changes from time to time in the prevalence of the various races of brown rust that are in any way comparable to the fluctuations already reported for races of blackrust though new physiologic races appear now and then and gain wide distributions.

(3) The proof that new races of rust may arise from time to time by hybridization or by mutation (knowledge summarised by Johnson and Newton 1946).

(4) The discovery that rust resistance may be of more than one kind. According to Stakman and Hart (1936) there are at least three rather clearly defined types of resistance in wheat to *Puccinia graminis tritici*. The first or physiological resistance as it is usually termed acts in all stages of plant growth, and is the result of incompatibility of the host and the pathogen resulting in killing of the cells of the former by the

fungs and the consequent death of the latter itself. The second type of resistance which has been studied mainly in relation to black rusts does not express itself fully until heading time or later and unlike physiological resistance, is apparently effective against all known sphysiological races. It appears to be due in certain varieties to morphologic characters such as the greater development of Sclerenchymatous tissues as the plant matures which limit the areas in which the fungus can grow Hart (1931). The other type of resistance which is recognised in functional resistance and apparently occurs in some varieties which have characters (*e.g.*, late opening of stomata) that make it difficult for the rust fungus to enter through the stomata.

(5) The discovery that environmental factors such as temperature and light may cure partial or complete breakdown of rust resistance in certain varieties. Thus Appel (1930) found that resistance to yellow rust was greately reduced by low temperatures ; Gassner and Straib (1934) also found the converse to be true *i.e.*, the high temperature increased the resistance of wheats to the same rust.

On the other hand with regard to black rust Johnson and Newton (1940) found that reduction in light intensity tended to influence Hope wheat in the direction of increasing susceptibility and constant high temperature (75—80°) was capable of breaking down, partially or completely, the mature plant resistance of this wheat, These authors also point out that mature plant resistance of certain varieties has been known to breakdown in Peru and Kenya where climatic conditions differ from those of North America.

(6) The demonstration that a few genes may govern the inheritance of resistance or immunity to a number of physiologic races so that as pointed out by Neatby (1942) groups rather than individual races constitute the "units" from the breeder's point of view.

In 1923 Aamodt showed that in a cross between Marquis and Kanred, of 13 physiologic races used, Kanred seedlings were immune to 8 and that a single gene governed the inheritance of the immunity to these eight. Goulden, Neatby and Walsh (1928) and Neatby (1931) revealed that the inheritance of seedling reactions to 18 races of black rust was mainly controlled by two pairs of genes in a cross between H-44-24 and Marquis. Many other studies have been conducted since.

The statement above refers to physiological resistance in the seedling stage. Mature plant resistance may be quite independent of seedling resistance (Hayes, Stakman and Aamodt 1925; Goulden, Neatby and Walsh 1928) and there is evidence that at least in some crosses it may be inherited in a simple manner (Clark and Ausemus 1928, Neatby and Goulden 1930 and Hayes et al 1934).

The Results already achieved in breeding for rust resistance.

Abroad.—Orton differentiated between disease-escaping, disease enduring, disease-resisting and immune varieties. A variety which while not truly resistant escapes diseases because of its earliness or some other reason may be of considerable practical value ; similarly a variety which

though attacked still manages to give a good outturn can also be of use. Keeping this in view, and also the facts that amongst resistant varieties various kinds of resistance occur, it is not possible to draw up a complete or an accurate list of the resistant varieties of commercial interest that have been discovered or bred. A partial list is however given below ; based mainly on the summaries published in *Plant Breeding Abstracts.*

	Resistant to black rust	Resistant to brown rust	Resistant to yellow rust
I. *Vulgare* ..	Saunders ..	Ford	Steadfast.
	Gabo	Sword	I. F. 293
	Charter	H. 51	I. F. 301
	Kendeo	H-622	Frontiera.
	Yalta	R-622/2	Surpresa.
	Celebration ..	H-49	Chinese 166
	Eureka	Quivira	Chinese 165.
	Eureka 2	Wabash	Roter Sommerkolben.
	Vesta	Tulun 3A/32 ..	T. *Vavilovi.*
	Webster	Ardito	
	Hofed		
	Febweb	Veronno	
	Rapier	Aurore.	
	Mabrook	Wester. Fultz.	
	122 D. I.. T(L) ..		Chargorod.
	117 E-16-. B. 1 ..	Kenya	Losostepka.
	117 B. 5. B. 2 ..		Ul'janooka.
	117 K. 16. A (L) ..	Wheats	Vorosilovskaja.
	117. I. 5. F (6) ..		Comanche.
	McMurachy's selection		Odessa 13.
	Pilot .. .. Thatcher .. .. Apex .. .. H—44—24 .. Kanred .. Kota		Chiefkan. Kawrale (Kawrale).
T. durum ..	Mindum .. lumillo ..	.. ..	.. ..
T. dicoccum ..	Khapli	..	..

	Resistant to black and brown rusts	Resistant to black and yellow rusts	Resistant to black and yellow rusts	Resistant to all three rusts
T. vulgare ..	Hope ..	Cote d'or	Zernogradka ..	Klein Exito.
	Mediterranean 3015—63	Cote d'or ..	Zernogradka ..	Klein Exito.
	Erythrospermum G. 19	Fylgia	Lutescens ..	162 Klein 157
	Erthrospermum G. 21.		Riccio ..	Klein Alberto
	B. 43 (U. S. S. R.)	..	..	Pionorka.
	H. 56 („)	..	..	Novo.
	Regent	..	..	Ukrainka.
	Mida ..	..	..	Reiti II.
	Newthatch ..	..	..	Hybrid 481.
	Austin ..	..	..	Porvenoc Horanka.
	Warigo ..	..	..	Arandamy.
	Sinvalocho M. A.	..	..	*T. fungicidum.*
	Rival ..	..	..	*T. timococcum.*
	Renown ..	..	..	*T. timopheevi.*
	F. P. I. 116326	..	..	*T. Sovieticum.*
	41—16-3-3	..		
	41—121			
	Okla—21			
	Montana			
	Cadö .			
	Coronation			
	Henry			
	Mercury			
T. durum ..	Gaza ..			
	Carleton ..			
	Stewart ..			

India.—The need for rust-resistant varieties was realized in the first decade of this century and work was actually started at Bombay Kanpur and Pusa. The earlier work in India was however carried out in the absence of the knowledge of the physiologic races present and of their relative importance and their fluctuations from year to year ; also selections were done on the basis of naturally-occurring rust incidence in the field. The result was that strains selected as resistant (*e.g.*, Howard 1933) proved to be susceptible when grown in other areas or when tested in later years under experimental conditions.

However the earlier work was not entirely without value and certain of the strains produced possess physiologic resistance to certain races and a fair amount of mature resistance to all or most of the races occurring in India. The most rust resistant of the older varieties was N.P. 120* (Shaw and Pal 1936) bred at Pusa and Karnal, which combined very considerable resistance to yellow rust at all stages with a fair degree of

* New Pusa—This prefix is applied to the strains bred at the Indian Agril. Res. Inst. these were formally known as Pusa, or Imp. Pusa (I.P.) strains.

mature resistance to all the three rusts. In the severe epidemic of black rust last year in Central and Peninsular India the following wheats were reported to have fared well, especially the first named ; N. P. 52. N.P. 4, N.P. 165, Pb. C. 591 and Niphad 4. They must certainly be considered to be more rust-resistant than the majority of the improved varieties grown by the peasant.

A series of new wheats bred by the author at the Indian Agricultural Research Institute was given a trial for the first time at a number of places last year when as just mentioned there was a severe rust epidemic over a considerable portion of the Central wheat-growing areas. Under these conditions, some of the new strains did very well. The comparative yield of three of the most promising strains is given in the statement below :—

	New Delhi	Nagina	Kanpur	Alwar	Basi	Beawar	Powarkhor. C. P
N. P. 710	121·23	116·05	110·88	168·92	223·72	548·44	583·38
N. P. 715	108·32	85·99	106·08	139·05	220·15	529·24	725·06
N. P. 761	..	..	..	182·31	215·39	..	666·72
Control	100·00	100·00	100·00	100·00	100·00	100·00	100·005
	(Pb. C. 591).	(C. 13)	(C. 13)	(Local)	(Local)	(Local)	(A. 11)

The very high increases contained at some places are abviously due to the greater ability of the new strains to stand up to the rust races concerned in the epidemic or in the case of N.P. 761 this may be attributed at least in part to its extreme earliness (it is slightly earlier than the earliest of the older N.P. wheats, which enabled it to fill its grains before the rust epidemic assumed its most destructive phase.

Systematic breeding of rust resistant varieties was started 12 years back based on the number of physiologic races found by Mehta. Since then some more races have been found. In wheat breeding work abroad, the breeder has been mainly concerned in breeding for resistance to one rust only. In northern India we have all the *three* rusts to be taken into account. Work was started at Simla, in Bombay and in the Central Provinces. At Simla the aim is to secure resistance to all the three rusts combined with other qualities acceptable to the cultivator. For this hybridization had to be done between foreign resistant varieties not suitable for direct cultivation in India and the best Indian wheats. Further as the object of the Simla scheme was to eliminate, at its source, the inoculum from the hills which infects the plains crop each year, Both seedling and adult resistance had to be aimed at. This work is being done by the writer in collaboration with Dr. K. C. Mehta.

Keeping the facts in mind, and the time when systematic breeding work for rust resistance was started, the progress has not been slow and has in fact been as good as anywhere else in the world. At Simla high resistance to all the physiologic races has been achieved separately for each rust and the work is at a stage when synthesis of resistance to all the three rusts simultaneously is being attempted by means of double cross made on a large scale. The Simla work is intended to provide rust resistant wheats for the hill areas only (the portion of the scheme submitted by the Indian Agricultural Research Institute elating to the plants those collected by the Indian Council of Agricultural Research by whom the scheme is formed.

In the Central Provinces and Bombay, the work is concerned with resistance to black rust only which is ordinarily the dominant rust in those provinces.

Although Indian work is very limited compared to what has been done abroad it must be remembered that unlike the position in Canada, United States of America and other agriculturally-advanced countries where the most progress in breeding for rust-resistance has been made resources in men and equipment devoted to this line of work have been meagre. Only the Punjab had a full-time agricultural botanist (Cerealist) working on the crop ; at the centre and in other Provinces wheat breeding work has been conducted by botanists who were in charge of a number of other crops as well. The co-ordinated rust scheme drawn up at the Indian Agricultural Research Institute and which with small modifications has been accepted by the Indian Council of Agricultural Research should be much to remedy this state of affairs and it is hoped that the scheme will be financed immediately and put into operation forthwith.

New resources available for breeding for rust resistance.

In America in the earlier work it was found that certain wheats belonging to *T. dicoccum* and *T. durum* (*i.e.*, the 28 chromosome group were more resistant to black rust than the *vulgare* varieties under study. Crosses were accordingly made between these species and *T. vulgare*. Although there was some difficulty occasioned by partial or complete sterility in some of the crosses specially these between *T. vulgare T. dicoccum*, and due to linkages between resistance and emmer and durum characters, it was found possible to transfer resistance from the emmer group wheats to *T. vulgare* an outstanding example being McFadden's cross between Marquis and a Yaroslav emmer (McFadden 1930) which gave rise to the well-known Hope wheat which along with other strain H. 44 from the same cross has been extensively used in N. America a rust resistant parent. Waterhouse (1933) referring to crosses between *T. vulgare* and Khapli (*T. dicoccum*) mentions that the *vulgare* variety Steinwedel crosses more easily with the wheat species than other varieties. In recent years other species of wheat have also been investigated more thoroughly and special attention has been drawn to the Transcacasian species T. Timopheevi (n=14). According to Jakubziner (1933-34) this species is resistant to all three rusts and Kostoff (1938) states that the investigations of Vavioy show that *T. Timopheevi* is immune to almost

all fungous diseases. Our experience in India however is that the species (or at least the two forms of it which are available) while highly resistant or immune to black and brown rusts can be attached quite appreciably by yellow rust. (On the other hand *T. Vavilovi* which is highly susceptible to black and brown rusts is highly resistant to yellow rust).

T. Temopheevi does not easily cross with *T. vulgare* but Shands (1941) has been able to do so, and Pridham in Australia has crossed it with the *vulgare variety* (Wenkoolz 1939) Pridham (1939) stated that F_3 segregreat from this cross showed apparent immunity to both stem and leaf rust.

Although Straib (1937) holds the opinion that the related genera of Gramineae are no more resistant than the cultivated cereals this view has not been shared by many others who have crossed wheat with rye, and related grasses such as *Aejilops Agropyron, Haynaldia* etc., (Kostoff 1935, Smith 1942 etc.). The Wheat-Agropyron crosses in Russia have particularly attracted much attention and a useful summary of the work on intergeneric hybridization between wheat and Agropyron has been given by Smith (1943). A detailed account of the rust-resistance of the wheat-Agropyron hybrids does not appear to be available but it has been stated that some of the annual forms from the crosses have complete resistance or even immunity to rust (Tzitzin 1938) 1939 (Verushkin 1935).

The modern development of the colchicine technique for producing fertile amphidiploids from crosses between species or genera that cross with difficulty or which give sterile hybrids has been made use and several amphidipoids have been produced including the following —

Wheat-rye (Lebedoff 1933)

T. *Timopheevi*—T. Monococcum (Kostoff 1936a, 1936b).
=(T. *Timococum* 2n=42.

T. *Timopheevi*—T. *durum* (Zhebrak 1940 b).

T. *durum* —T.—*vulgare* (Zhebrak 1940 b).

T. *Timopheevi*—T. *turgidum* (Zhebrak 1941b)
=T. Svieticum : 2n =56)

T. Timpphheevi—T. *vulgare* (Zhebrak 1941 b).

Detailed rust reactions of the progney are not available to the writer but Kostoff (1938) states that *T. Timococcum* is completely immune to all fungus disease. It is also stated (Ann. 1944) that *T. Sovieticum* is resistant to most fungus diseases. Zhebrak (1944) points out that the amphidiploids of *T. Timopheevi* are not fit for immediate introduction to cultivation but are useful for plant breeding.

In India interspecific crossed between *T. vulgare*, *T. durum*, and T, dicoccum have been attempted in the C.P., also in Bombay by Kadam who also used *T. Timopheevi* as one of the parents.

In the Punjab, Ram Dhan Singh tried to cross wheat with barley and *rye*. The latter was successful but the F_1 was sterile. Most of the work on interspecific and intergeneric crosses has naturally been done at the Indian Agricultural Research Institute and its substation at Simla.

There a very large number of interspecific and intergeneric crosses have been attempted since 1936-37. These studies have yielded useful information regarding the crossability of different species and genera, fertility of the hybrids and the relative utility of the progenies from practical and the fundamental viewpoints. Below is given a list of interspecific and intergenerics crosses where genuine F_1 hybrids were obtained.

	Female parent	Male parent	Remarks
Intergeneric	1. *Triticum vulgare* (N. P. 4) (N=21)	*Secale cereale* (rye) (N=7).	A solitary seed was obtained from a fairly large number of F1 plants.
	2. *T. vulgare* (N. P. 165) n=21).	*Aegilops caudata* (N= =14).	Do.
	3. T. *sphaerococcum* (N =21) Indian dwarf wheat).	*Secale cereale* (rye) (n= =7).	completely sterile.
	4. T. *dicoccum* (Khapli) (n=14).	Secale cereale (U=7)	Completely sterile.
	5. *Aegilops triuncialis*	Secale cereale (n=7)	Completely sterile.
	6. A. *ventricosa* (n=14)	Secalecereale (n=7)	Completely sterile.
	6. A. caudata (n=14)	T. aegilopoides (n=7)	Completely sterile.
Inter specific ..	1. *Triticum monococum* (Einkorn) n=7	T. *Timopheevi*=(n=14)	Completely sterile.
	2. *T. durum* (n=14)	T. Vulgare (n=21)	Fairly highly fertile.
	3. *T. durum* (n=14)	*T. Vavilovi* (n=21)	Fairly highly fertile.
	4. *T. durum* (n=14)	*T. dicoccum* (n=14)	Fully fertile.
	5. *T. dicoccum* (n=14)	*T. vulgare* (n=21)	Fairly highly fertile.
	6. *T. Timphecvi* (n= 14).	*T. monococcum*	Completely sterile.
	7.*T. Timopheevi* (n=14)	*T. yulgare* (n=21)	Completely.
	8. *T. polonicum* (n=14)	*T. Vavilovi* (n=21)	Fairly fertile.
	9. *T. vulgare* (n=21)	*T. sphaerococcum* (n= 21).	Fully fertile.
	10. T.Uvulagre (n=21)	T. Vavilovi (n=21)	Fully fertile.
	11. T. Spelta (n=21)	T. Vavilovi (n=21)	Fully fertile.

From the above it would appear that some of the rust resistant species of *Triticum* referred to earlier *viz.*, *T. Timopheevi* (resistant to all the rusts), *T. dicoccum* and *T. durum* (resistant to black rust,), T. Vavilovi (resistant to yellow rust) have been successfully crossed with T. *vulgare* (common bread wheat) or other species crosses which may indirectly prove useful in breeding for rust-resistance. From some of these fertile crosses

promising selections have been made which show high resistance to certain individual rusts combined with good ear and grain characters. But as has been indicated before our objective is to induce resistance to three rusts simultaneously. This however it has not been possible to achieve from this material.

From amongst the intergeneric crosses mentioned above two, *viz.*, wheat $\times$ rye and wheat $\times$ Aegilops have been studied up to seven generations starting with a solitary F_2 plant in each case. The selections from these crosses have also been tested for adult resistance by means of artificial epidemics. Though some of these have shown resistance to one or more rusts they possess certain other characters such as late maturity, week straw etc., which render them at present unsuitable for commercial purposes. It may, however, be mentioned that these crosses have yielded some interesting genetic variability for further use.

The outlook.

It has been made clear that the problem of overcoming the wheat rusts is one of great magnitude and complexity. Three rusts, each capable of completely destroying the wheat crop occur ; further within these a large number of physiologic races occur and new races may arise as the result of hybridisation or mutation. The degree of resistance to the rusts desired to afford complete protection to the grower has to be obtained from a number of species some of which only cross with difficulty or give rise to sterile hybrids ; again the resistance may be linked with undesirable characters. Also as has been pointed out, differnt types of resistance occur and some of these affected by factors such as tempera-true light, etc., it is probable that as many of these as possible should be combined in order to obtain wheats which will maintain their resistance over a range of conditions.

On the other side hopeful features exist such as the fact that resistance to whole groups of physiologic races may be controlled by a few genes inherited comparatively singly, and that mature plant resistance found in certain varieties usually embraces resistance to all the races of a rust. Also with improved genetical technique new sources of resistance have become possible such as the related genera of the Gramineae, and the amphidiploids such as *T. Timococcum* which have been artificially produced. In India there are further redeeming features in the situation in that the total number of physiologic races occurring in the country is small (Mehta and Pal 1940), and Mehta (1940) has pointed out that the number is not likely to increase much as the alternate hosts of the black and brown rusts (no alternate host is known for yellow rust) do not appear to play a part in the perennation of these rusts, and hence the danger of new races arising in nature as a result of hybridization is negligible.

It is evident that one of the reasons why much headway has not been made in India in breeding for rustlresistance is that until about twelve years ago the necessary knowledge about the physiologic races occurring in the country and the means of testing varieties against them was not

available. Even after that the work has been practically restricted to three centres, *viz.*, the Simla substation (where varieties suitable *for the hills,* resistance to all the three rusts in all stages of the plant's growth were required and in Bombay and C.P. where the problem is simpler and only resistance to the black rust in the adult stage is mainly required.

It must be emphasized that work of this nature cannot be successfully carried out as one of the lines of work of a plant breeder who has also to look after work on a number of other crops. In the countries where most success has been achieved, wholetime organizations devoted to the problem of the cereal rust and their control exist. The co-ordinated wheat scheme already referred to is an attempt to remedy the situation by providing the essential staff and equipment required, keeping in view the limited financial resources of the country. It is hoped that the scheme will be brought into operation without delay for reward of successful work on the control of the wheat rusts is exceedingly great. In Canada Neatby (1942) was able to say, as a result of the successful breeding programme, that "conquest of stem rust of wheat in the hard red spring wheat area of Canada and adjacent states is for the time being at least complete." Let us hope that inside of a decade we may be in a position to say the same about the major wheat-growing areas of our country.

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Subject No. 3

CEREAL RUSTS AND THEIR CONTROL.

R. B. Ekbote and K. R. Sahasprabudhe, Wheat Research Station, Powerkhera, C. P.

Few diseases, if any, of the cultivated crops in India, are so menacing as the wheat rusts. In Central Provinces and Berar, where black stem rust, *Puccinia graminis trilici*, is of common occurrence, the damage sustained by the crop is considerable. In the last two destructive epidemic years, 1943-44 and 1946-47 the loss was of the order of Rs. 4 and 17 crores respectively. Although the damage in the latter year was unprecedented, every third or fourth year the crop suffers the same extent, more or less, as in the year 1943-44. The fact that there is almost a complete lack of irrigation facilities in the wheat growing areas, may lead one to infer that moisture deficiency is the limiting factor in wheat production in the Province. It has, however, been observed that wet growing seasons are as unfavourable as the dry seasons and in some years even more. Winter rains do prove beneficial to the crop growth but they also induce severe infection of rust, with the result that seasons which appear favourable turn out calamities in the end.

2. Accordingly to Dr. K. C. Mehta, the annual outbreaks of stem rust in Central Provinces and other parts of the peninsular India, occur as a result of over summering of the disease on the monsoon wheat crop grown in the Nilgiri and Palni Hills in South India. By the time the normal crop is sown there is abundance of rust inoculum on this off-season crop, which is bloom by wind to Mysore Bombay, Hyderabad and Central Provinces. In this view, suspension of cultivation of this rainy season wheat crop, which is the source of infection would control the rust epiphytotics in peninsular India. Recently in the course of a survey undertaken for the search of collateral hosts, a wild grass, *Vulpia mysuros* was found infected with this stem rust. This discovery has an important bearing on the control measure advocated by Dr. Metha. If the off-season wheat crop is not the only source, carrying the disease from one season to another suspension of its cultivation, by itself is not enough. At the most, it would reduce the amount of rust inoculum causing initial infection of the normal crop. Subsequent progress of the disease would depend upon weather conditions. While contemplating the control measure recommended by Dr. Mehta the role of *Vulpia myuros*, and other collateral grasses if there be any, in causing rust outbreaks, must be properly assessed, for which sake a thorough survey of the wild grasses must be undertaken in Nilgiris Palnis, Satpuras etc. In the mean time substitute crops may be recommended for cultivation in place of the monsoon grown wheat crops.

3. As regards phrophylactic measures, *viz.*, dusting of sulphur or kolodust, the experience gained in the other wheat growing countries is not encouraging. The dose of the fungicide time and number of

dustings depend upon the intensity of infection and weather conditions. Besides the cost involved has been found to be prohibitive. This method of control of rust on a large scale is therefore unfeasible. It may however be possible to undertake this measure for protecting seed areas to ensure adequate seed supply for future sowing. The details and expenditure involved will have to be worked out.

4. Cultural practices such as early sowing, phosphatic manuring and cultivation of semi-resistant or rust tolerant varieties like M.P. 52 be recommended to minimise the damage. In Central Provinces, early sowing and growing of M.P. 52 and other rust tolerant wheats have been found to lessen the damage.

5. The most effective and feasible means of combating this dreadful disease is the breeding of frust-resistant strains. This work, which is full of promise should be intensified. Considerable progress has been made in U.S.A., Canada, Australia and varieties possessing high degree of field resistance have been produced and cultivated on a large scale. There have been a few cases of breakdown of the rust-resistant wheats, due to the appearance of new races, to counteract which possiblity, breeding investigations are continued to build up new strains. In India, where the rust fungus perpetuates only in the vegetative stage from year to year, the possibility of new races of biotypes springing up as a result of hybridization is little. Mutation may occur in the existing races but not to any appreciable extent. It is therefore time that adequate funds and facilities are provided to undertake this universally aclaimed method of rust control on a scale commensurate with the area, frown under wheat and the extent of loss incurred. In each affected province or state, there must be couply of breeding stations to speed up the desired results. Along side, identification of races by analyses of large samples of rust must be undertaken at a number of stations and the fundamental problems of mutation, disappearance and re-appearance of races relative viability of different races at different temperatures and humidity, their incubation period and relative virulence under natural epuhytotic incidence investigated.

APPENDIX IV.

Notes read at the meeting on subject No. 4.

Pages.

By.—

1. K. B. S. Abdul Hasan.
2. Mr. N. P. Bhagwat.
3. Lt. Col. C. A. MacLean.
4. Mr. K. C. Ramkrishna.
5. Dr. P. C. Raheja.
6. S B. Harchand Singh.

SUBJECT No. 4.

MODEL VILLAGE DEVELOPMENT SCHEME.

(S. ABDUL HASSAN, M.B.E., KHAN BAHADUR PRESIDENT, COURT OF WARDS U.P.)

Consolidated Farming.

The Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India examined the question of increasing production of agricultural commodities and recommended that steps should be taken to introduce consolidated farming in villages so as to save labour and increase production by timely tillage operations, bunding, sowing at the right time, irrigating jointly, controlling pests and diseases, hard vesting at the proper time, and marketing jointly. The yields obtained from such farms were to be compared with those from ordinary methods of farming where feasible with those of consolidated farming. The Imperial Council of Agricultural Research wrote to Provincial Government in July 1944 expressing the hope that the Provincial Government will take action on the lines recommended by the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India. They explained that the term "consolidated farming" denotes a system in which cultivators in a village agree to grow each main crop in one or more consolidated blocks instead of in scattered fields as is the common practice now. The cultivators would so arrange their croppings that each would sow his crop in fields adjoining the field of his neighbour under the same crop. The Provincial Government consulted the Court of Wards about the possibility of consolidated farming. I undertook to carry out the experiment. In consultation with the local officers I selected village Sarthua belonging to the Gopalkhera estate under the Court of Wards in district Lucknow.

Genesis of Development Scheme.

2. I had already prepared a plan for general agricultural improvements in Court of Wards villages mainly by taking advantage of the activities of the U.P. Agricultural Department as explained in my pamphlet "Planning of agricultural improvement in Court of Wards villages" The move made by the Provincial Government regarding the possibility of consolidated farming offered a fresh opportunitty for initiating intensive work. The need for increasing agricultural production is now universally recognised and no arguments are required in support of it. While examining the possibility of introducing consolidated or block farming in village Sarthua I thought it was first necessary to study the economic features of the village and then to prepare a comprehensive scheme for agricultural development which can be translated into practice without much difficulty in co-operation with the agriculturists. The experiment which has been made in described in the following paragraphs and the experience which has been gained has seved material for a model scheme which might well be tried in other similar villages.

Economic Features of Village Sarthua.

3. (i) A short description of village Sarthua and its economic features may be given. The village is situated about 12 miles southeast of Lucknow. The Utratia-Goshainganj distributary of the Sarda canal runs just outside the northern boundary, while the Lucknow. Nagram unmetalled road passes through the east of the village. The nearest railway station lies at Utratia about 1¼ miles from the village. The Government seed depot is about 4 miles off. The village is readily accessible from the city of Lucknow. The gross rental of the village is Rs. 2,208 and the land revenue payable to Government is Rs. 540. The total area of the village is 564 acres of which 254 acres is cultivated. The eastern half on either side of the Lucknow-Nagram unmetalled road consists of inferior cultivation interspersed with usar patches and rice depressions which grow both early and late rice. The south-west, north and north-west and the centre have fair blocks of good level loam which grows *rabi* crops after early rice. The low land is liable to flooding by the neighbouring jhils during heavy rains. The irrigated area is 125 acres of which 65 acres is irrigated by canal and 60 acres by tanks. There are 13 masonry wells of which 9 are used for irrigation. According to the soil classification made at the last settlement of the village in 1928 the distribution of soils is as follows :—

Loam	Acres
Class I ..	48
Class II ..	85
Class III	54
Class IV ..	25
Ekfasli rice	38
Others ..	7

The tenants are mostly Lodhs. The next in order are Pasis. There are 114 families living in the village. Of them 72 are principally dependant and 11 party dependant on agricultural while 31 have got no land at all and have to earn their livelihood by other occupations. In addition to 83 *dehi* or resident tenants mentioned above there are 18 *pahi kasht* or non-resident tenants. The area cultivated by *pahi kasht* tenants in this village is 16 acres, while 17 tenants of this village cultivate 32 acres land in other villages. The average area of the holding of a resident tenant works out to 5.3 bighas (3.3 acres) which is much below the average of 7.8 bighas (4.9 acres) in the Lucknow District. This is due to the high density of population in this village. The main crops are rice and wheat with a fair proportion of vegetables. The cultivating tenure is a complex one. Out of the 108 khatauni khatas, 89 are held by hereditary tenants, 14 by under-proprietors and 5 by muafidars. The vast majority of the land is held by hereditary tenants. In brief, the population is high, the tenants are mainly Lodhs, the soil is good loam, the holdings are small and the facilities for irrigation good.

(ii) *Distribution of holdings*—The size of the holdings of resident tenants is given below :—

Area (in acres)	Number of tenants	Total area held (in acres)	Percentage of tenants to total number of tenants
(*i*) 1 to 2½	42	56	51
(*ii*) 2½ to 5	30	114	36
(*iii*) 5 to 7½	7	44	8
(*iv*) 7½ to 10	..	..	..
(*v*) 10 to 12½	3	34	4
(*vi*) 12½ to 15	..	..	..
(*vii*) 15 to 17½	1	16	1
Total ..	83	264	100

The holdings of about half the tenants are tiny and average only 1.3 acres per tenant's family. The next largest group, *i.e.*, more than 1|3rd, consists of holdings between 2½ to 5 acres with an average of 3.8 acres per holding. There are only 11 tenants, 1|8th of the total number of tenants, who have comparatively large holdings exceeding 5 acres.

(iii) *Cattle Stock*—The following table gives details regarding cattle stock of the village :—

Bullocks used in ploughs	120
He-buffaloes used in ploughs	14
Cows	30
Calves and heifers	68
She-buffaloes	40
Sheep and goats	36
Ploughs	67
Carts	9

The distribution of holdings may be studied in relation to cattle stock. There are 10 tenants who have two ploughs and two pairs of bullocks each. This corresponds to substantial tenants whose holdings exceed 5 acres each. There are 46 tenants possessing one plough and one pair of bullock or one pair of he-buffaloes 39 with one pair of bullocks and 7 with one pair of he-buffaloes each. Two tenants have one bullock each with a plough in common between them. Out of 83 tenants in the village there are 58 who have ploughs and bullocks as stated above while 5 live jointly with others. There are 20 tenants who have no bullocks at all and have either sub-let their land on *batai* or depend on hired bullocks for their cultivation. The latter are those who have got very tiny holding less than acre each. It is obvious that the cultivation of land by tenants who have no ploughs and bullocks is but indifferent.

There is a wastage of bullock power in the village. The number of bullocks increases with the number of cultivators while the average

size of holding decreases with an increase in the average number of cultivators. In order to determine the wastage in bullock power, cattle were classified in 3 grades according to their working capacity. In grade A were put cattle which are capable of working a holding of 6 acres in a year, in grade B those who could do 5 acres and in grade C only 3 acres. The following table shows the number of cattle of each grade with their working capacity in acres :—

Grade	Pair of cattle	Cultivating capacity (in acres)
A	15	90
B	32	160
C	12	57
Total ..	60	307

Thus the total area which could be cultivated by 66 pairs of cattle is 307 acres while the total cultivated area of the village is only 254 acres. There is a theoretical wastage of bullock power in this village but a number of bullocks are decrepit and semi-starved and have little working capacity. Nevertheless they are fed for all the twelve months to work ordinarily for not more than 110 days a year consuming the *much needed fodder. There are practical or sentimental difficulties.* A pair of bullock has to be maintained because plough cannot be done only by one, individualistic instinct and the distrust of the neighbour are deeply rooted. In spite of the small size of his holding, a cultivator prefers an inferior pair as he cannot find work for a better one even though he can afford to purchase and feed one ; then the bullocks have to be maintained throughout the year because the work on the holding is intermittent and there is no other work on which cattle can be utilised. The number of carts is very small and the spare time of the bullocks is not fully utilised in running those carts.

The position of milch cattle in the village is extremely unsatisfactory. There are 30 cow and 40 she-buffaloes, total 70—most of them half-starved and useless. The total yield of milk is 65 seers per day and about 1|3rd is taken to Lucknow and sold there. The milk supply is grossly inadequate for a village consisting of 545 inhabitants of whom boys and girls alone number 267 The obvious solution would be to replace the unnecessary number of bullocks by cows or she-buffaloes. This will not affect the fodder supply but would certainly increase the yield of milk which is so much required for the health of the people. The wastage in bullock power could be avoided by group farming which would be explained later on.

Formation of Consolidated Blocks.

4. Unfortunately there was no precedent regarding consolidated farming in these provinces and there were no reports which served as a guide Any scheme of agricultural improvement which may be introduced in an agricultural year commencing from July 1, has to be worked out long before the commencement of the year. It was proposed to introduce consolidated farming in village Sarthua in the fasli year 1953 commencing from July 1, 1945. A special staff consisting of an inspector

of agriculture, two *kamdars* and a *muharrir* was appointed in February 1945. The cost of the staff and contingencies was provided by the Provincial Government. The preliminary work regarding the preparation of records was started in that month. There was some opposition on the part of tenants in the beginning but it was overcome when they realised what the scheme was and what benefits it was likely to confer.

The formulation of proposals regarding consolidated farming presented practical difficulties. The selection of a compact block in which the same crop was to be principally sown had to be made. This could not be done at random. The entire cultivated area was carefully inspected with the help of the soil classification map prepared at the last settlement of the district in 1928. It was necessary to know whether a field in a block was suitable for the crop which was to be sown in the block. The khasra or field book of the village was prepared in a tabular form showing the chop sown in each field during the last three years, *i.e.*, 1350 to 1352 F. The fields which were irrigated were marked. The soil classes were entered. All homogenous land of similar quality was grouped in one block. For instance, from the block marked for early rice and wheat, high-lying and low-lying lands were excluded. The land of light soil was grouped separately. The requirements for fodder for cattle were not ignored, and tenants had to be accommodated to provide for special conditions. When a tenant's holding consisted of only one plot and was situated at the extremities, it was excluded as far as possible so that he may grow a crop of his own choice. In this village a fair area of vegetables is sown and is very paying owing to the proximity of the village to Lucknow. Hence no restriction was imposed on vegetable cultivation inside the blocks. In the course of experiment in a subsequent year, the year in which a field was manured during the previous three years was noted down after local enquiry to determine the extent to which land was manured each year and to plan out the system of manuring in future years.

The blocks were carved out in consultation with the village people having regard to the suitability of the soil for crop. They were marked on the soil classification map of the village to show at a glance whether the proposed block was generally suitable for the proposed cropping. A certain proportion of land which was either scattered or was outlying was left out partly because it could not form part of a compact block and partly to enable a tenant to make up for any deficiency in the area of any particular crop which might have resulted in an individual holding owing to consolidated farming. There are 12 tenants whose holdings lie entirely inside the blocks; 13 whose holdings lie wholly outside the blocks; and the remainder have their holdings partly inside and partly outside the blocks. The area of the land inside the blocks as well as that outside the blocks for each crop was totalled and precentages struck in order to compare them with the average distribution of crops in the previous three years. This was necessary to determine whether there had been an improvement or deterioration in the system of cropping and whether the crop economy of the village had not been disturbed,

The proposals were published in the village for objections but none were received as the blocks had already been carved out in consultation with the village people.

The total cultivated area of the village is 254 acres out of which 10 blocks as shown in the map have been made with an area of 151 acres. Thus about two-fifths of the cultivated area of the village was excluded from the blocks. The area of the blocks and the crop sown therein are shown in the following table :—

Serial No.	*Name of block*	*Area of block* (in acres)	Crops sown.	
			Kharif 1353 Fasli	*Rabi* 1353 Fasli
1	A	48·0	Early rice ..	Wheat.
2	B	10·0	Late rice ..	Gram.
3	C	13·7	Juars-arhar	Arhar.
4	D	8·8	Early rice ..	Barley.
5	E	19·4	Fallow ..	Wheat.
6	F/1	6·0	Early rice ..	Gram.
7	F/2	8·2	Late rice ..	Do.
8	G	18·8	Do. ..	..
9	H	11·2	Fallow ..	Wheat.
10	I	6·9	Sanai for green manuring.	Do.
	Total ..	141·0		

The cropping has to be planned according to proper system of rotation. There are three blocks in which early rice was sown in kharif. It was followed in rabi by wheat in block A which is the best and most fertile block in the village and lies adjacent to the abadi : by barley in block D and by gram in block F|1 which has stiffer soil. There are three blocks of late rice. In two of them gram was sown in rabi while the third which was low-lying is only fit for *ekfasli* crop. There was only one block of *juar-arhar.* There were three blocks which were meant for wheat. Of them two were fallow in kharif and the third was sown with *sanai for green manuring.* It was not possible to reduce the number of blocks otherwise the rotation of crop would not have been ensured.

..Justification of Cropping Inside And Outside The Blocks

5. The proposed cropping both inside and outside blocks has to be justified. The distribution of crop is shown in the accompanying table.

		Total culti-vated area in acres	*Kharif*						*Rabi*					
			Early rice	Late rice	Juar arhar	Vege-table	Other crops	Total *kharif*	Wheat	Gram	Peas	Vege-tables	Other crops	Total *rabi*
1. Average cultivated area of the village during the three years viz. 1350 to 1352 Fasli.	Area ..	254·4	50·0	51·9	30·0	14·4	46·9	193·2	73·1	21·2	12·5	9·4	20·9	136·2
	Percentage to total area.	100	19·0	20·4	11·8	5·6	18·4	75·9	28·7	8·4	4·8	3·7	7·9	53·5
2. (a) Cultivated area in the block in 1353 Fasli.	Area ..	150·6	40·0	35·0	13·7	10·0	3·1	101·8	62·5	16·9	..	8·7	6·9	95
	Percentage to total area.	100	26·5	23·2	9·1	6·6	2·8	67·5	41·5	11·2	..	5·8	4·5	63·0
(b) Cultivated area outside the block in 1353 Fasli.	Area ..	103·7	10·6	24·4	15·6	9·4	32·5	92·6	16·9	2·5	11·2	1·3	12·5	44·4
	Percentage to total area.	100	10·3	23·5	15·0	9·0	31·3	89·1	6·3	2·4	10·8	1·2	12·0	42·7
(c) Total area inside and outside blocks in 1353 Fasli.	Area ..	254·4	50·6	59·4	29·4	19·4	35·6	194·4	79·4	19·4	11·2	10·0	20·4	139·4
	Percentage to total area.	100	19·9	23·3	11·5	7·6	14·0	76·3	31·2	7·6	4·4	3·9	7·6	54·7

Based on the three years' average (1350 to 1352F) the main kharif corp of the village are early rice (19.7 per cent) and late rice (20.4 per cent.) folowed by juar-arhar (11.8 per cent). The main rabi corp is wheat (28.7 per cent.) After a big drop comes gram (with 8.4 per cent.) The area under vegetables which is the most lucrative crop is fairly good, being 2.6 per cent. in kharif and 3.7 per cent. of the total cultivated area of the village in rabi. The area of miscellaneous crops was 18.4 per cent. in kharif and 7.9 per cent. in rabi. There has been an improvement in cropping in 1353 F. Taking the village as a whole, the area of late rice has increased from 52 to 59 acres, of vegetables from 14 to 19 acres and the area of miscellaneous kharif crop has decreased from 47 to 36 acres. In rabi 1353 F. the area under wheat has decreased from 73 to 70 acres. The improvement in cropping has been effected at the expense of the poor crops.

As would be expected the main crops have been concentrated inside the blocks and the miscellaneous crops have been reduced. For instance, the average of three years 1350 to 1352 F. shows that in block A early rice covered 32 acres, juar 12 acres, maize 5 acres but in 1353 F. the whole of the block excluding vegetables was sown with early rice. In the same block in rabi there were formerly 29 acres under wheat, 9 acres under gram, 8 acres under peas, 6 acres under mixed barley and gram and 6 acres under arhar. The plots under the various crops were formally interspersed. But in 1353 F. the whole of the area in the block excluding vegetables was sown with wheat in rabi.

Agricultural operations of Consolidated Farming.

6. (1) *Ploughing, sowing hoeing etc.*—The ploughing was done with greater care than before. A few improved ploughs were also used. Formerly some were indifferent in ploughing and hoeing etc., and sowing was done at different times. But, as a result of consolidation of farming, the agricultural operations in all the fields in the same block were done with the same care. These operations were regularly supervised by the agricultural inspector to ensure good cultivation.

(2) *Seeds.*—Formerly seeds of different varieties were sown. But during the year improved seeds of the same variety were obtained from the seed depot and sown in the same block. Thus purity of seed was ensured.

(3) *Manuring.*—About one-third of the cultivated land belongs to second class loam as demarcated at last settlement in 1928. This area can easily be raised to the level of first class loam if it is properly manured The deficiency in manuring has received attention in the course of consolidated farming. In the first year of the experiment *sanai* was grown in block I in an area of 6.9 acres for green manuring. The soil consists mostly of second class loam but was not well manured in the past. In order to increase fertility of the soil green manuring was done in this block for the purpose of sowing wheat in rabi. One ton of ammonium sulphate was also supplied for demonstrating the effects of its application. Block D which has an area of 8.8 acres lies

at the farthest end of the village and did not get a share of the manure in the past as the nearer fields did. The whole of the block consisted of second and third class loam. Ammonium sulphate was used in kharif in paddy field in block D at the rate of 3 maunds per acre. The paddy crop magnificient and was greately appreciated in the neighbourhood.

Formerly cow-dung and refuse were stored in a heap above the ground. This resulted in loss of good manure. In order to increase the quality and quantity of natural manure tenants were persuaded to store cow-dung, refuse, leeves and earth soaked in urine of cattle in manure pits. They were advised to spread leaves and earth beneath cattle and to throw the earth and leaves soaked in urine in the pits. In the beginning 88 compost pits were made having a size of 6ft. ×4ft. × 4ft. At the end of the year the number of manure pits had increased to 200. They were arranged systematically in rows at convenient places outside the abadi. The tenants have appreciated the utility of these pits in increasing the quality and quantity of natural manure. This is a great achievement which has come to stay.

(4) *Irrigation.*—Irrigation is done mostly from Sarda Canal. The alignment of irrigation channels was defective and wasteful in the past. The channels were realigned to suit the irrigation of fields in a block. It is admitted that as a result of consolidated farming irrigation has been facilitated and waste of water was avoided. The results in rabi would have been better than what they were but for the fact that owing to the failure of winter rains the supply of canal water was inadequate and intermittent.

Results

It is difficult to measure the effect of consolidated farming upon the yield of crops. An extract from the report prepared by the Special Manager, Court of Wards, Lucknow (Mr. P. S. Varma) received through the Deputy Commissioner and Commissioner, Lucknow regarding an estimate of the increase in the yield is attached to this note for reference. A comparison with previous year is difficult partly owing to the absence of any record of yield in the previous year and partly to the difference in weather conditions. The Special Manager has compared the yield inside blocks with those outside them. According to him the yield inside the blocks has increased as compared with that outside the blocks by percentages varying from 10 to 34 per cent. While there is an improvement in consolidated farming inside the blocks over the fields outside the blocks where ordinary methods of farming were applied, there is a slight difference in the quality of the soils inside and outside the blocks. Making allowance for all the factors and after taking into consideration the views of the villagers and after discounting for the use of ammonium sulphate in block D, I have no hesitation in coming to the conclusion that the yield of the crops has definitely increased by the adoption of consolidated farming and that the increase may be safely estimated at about 15 per cent. as compared with the yield of land from ordinary methods of farming.

Group Farming

8. Towards the end of paragraph 3(iii) it was stated that wastage in bullock power could be avoided by group farming. in my pamphlet on "Consolidation and improvement of Holdings in the United Provinces". I have defined group farming a system of farming by a group of homogenous cultivators or farming by a combination of cultivators who have no ploughs or have deficient bullock power with those who have an excess of it. To try this system of farming, it is first necessary to determine how many tenants have standard holdings: The area of land which can be cultivated by one plough and a pair of bullock having regard to the nature and the productivity of the soil, irrigation and the bullock has been termed by me in that pamphlet as "standard" holding. The standard holding can conveniently be measured by plough duty—a settlement term which means the average cultivated area per plough.

The result of the classification of bullocks according to their cultivation capacity has already been described in para. 3(iii). It has been found in village Sarthua only four tenants had standard holdings and 46 had excess bullock power while the bullock power was deficient in the case of 33 tenants. It is proposed to join the tenants having deficient bullock power with those who have an excess of it. The cultivator with deficient bullock power would provide labour in ploughing, hoeing or in irrigation in return for an equal amount of bullock power when required in his own field. The tenants are agreed that for the purpose of group farming one day's bullock power will be taken as equivalent to 4 days man power. To begin with 4 units of the following tenants whose holdings are situated close to each other have been selected for group farming.

Serial No.	Particulars of tenants with excess bullock power				Particulars of tenants having deficient bullock power		
	Name of tenant	Area of holding (in bigha)	Number of bullocks	Class of bullocks	Name of tenant	Area of holding (in bigha)	Number of bullocks
1	2	3	4	5	6	7	8
1	Kallu and Piarey Pasi.	11	1 pair	A	Bhagna Pasi ..	1	
2	Gurdin Kori ..	2	1 pair	C	Kaunhai Dhobi	2	
3	Kamta Chamar	3	1 pair	C	Keola Chamar	2	
4	Babulal Lodh ..	6	1 pair	A	Pushai Barber	1	

Other Improvements

9. (i) The organisation of the Rural Development Department has been extended to village Sarthua A multi-purpose society has been formed and the panchayat is consulted about consolidated farming and other matters. Among the improvements which have in this connection been

completed are the construction of soakage pits, repair of drinking wells and of bye-lanes and roads of the village, demolition of old khandars, etc.

(ii) With a view to improve the adjoining land a new hamlet with model hoses after the pattern approved by the Rural Development Department has been established at the far end of the village by the side of the Lucknow—Nagram road. A bazar has also been established at the new hamlet at the cost of the Gopalkhera estate. It is hoped that this bazar will give an ample return to the estate after sometime and will also be a convenience to the villagers who had so far to go 5 miles to the nearest bazar.

(iii) In addition, fuel plantation is being done in an area of 10 acres.

Conclusion.

10. The above is the report of the result of the experiment on consolidated farming in village Sarthua in the year 1353F. (July 1, 1945 to June 1946). The period of the experiment is a short, one yet the lesson, which has been learnt has justified the continuance of the experiment in the village and its extension to a neighbouring village. Luckily the village was not affected by any agricultural calamity during the year. But tenants have readily admitted the advantages of consolidated farming and are not willing to give it up. They realise that damage is done by rats when scattered wheat fields are surrounded by arhar fields. The damage is avoided in having a compact block of wheat. There is facility in irrigation and in keeping a watch over the crops. What is important is that the purity of seeds is secured. The sowing, hoeing and reaping are done at proper times. The extent and system of manuring have received greater attention than before. An essential part of consolidated farming is the planning for agricultural operations and improvements. The formation of blocks takes time and has to be made after careful study. I would have preferred the village panchayat specially formed for the purpose to carve out blocks for themselves. In fact I asked the people of a neighbouring village whether they could do so but they expressed their inability in the matter. I do agree that in the beginning our tenants want guidance and help. It would not be difficult for an agriculture inspector gradually and ultimately to supervise the work of consolidating farming in six neighbouring villages. But this does not mean that he can initiate consolidated farming simultaneously in all the six villages in the same year. In the beginning the work would be heavy. The agricultural operations will have to be supervised and indifferent farmers will have to be stimulated, helped and encouraged. But the amount of guidance would decrease with each subsequent year. The introduction of agricultural improvements is facilitated by the adoption of the system of consolidated farming. I am of opinion that this system is full of promise for the future ; and if its utility is fully established by experience, it would be necessary to give legal powers to provide for its extension with the help of village panchayats over a wide area which is found to be suitable for consolidated farming.

Future Planning

11. The selection of a village for consolidated farming in the early stages of the experiment on voluntary basis requires great care. The village should be inspected and economic feautres consisting of cropping, irrigation, cultivating castes and proprietary tenures should be examined. The village should have facilities for irrigation and should be preferably situated within the command of a canal. The successful execution of agricultural improvements cannot be fully ensured without adequate irrigation. Tenants should be consulted and should be willing to adopt the method of consolidated farming. Having selected the village, the following records should be obtained or prepared :

(1) a copy of the map of the village showing the latest soil classification made at settlement or roster operations ;

(2) a khasra or field book of the village showing names of cultivator, class of soil, cropping, irrigation and manuring during each of the last three years ;

(3) a record regarding distribution of holdings and agricultural stock ;

(4) proposals regarding formation of blocks for consolidated farming in consultation with the village people. These proposals should be published for objectionss and levissed in the light of the objections that may bv received.

Finally a scheme should be prepared more or less on the lines of this pamphlet giving an account of the economic features of the village ; and justifying the proposals for the formation of blocks by comparing the cropping inside and outside the blocks with the average of previous three years and explaining the improvement proposed in the system of cropping. The plan for agricultural improvement should be stated—the procurement of good seed, the making of compost or manure pits, green manuring or the quantity of artificial manure required, the making of *daulbandi,* the re-alignment or remodelling of irrigation channels. The extent of manuring has to be increased by increasing the quantity and quality of natural manure by making compost or manure pits or by green manuring and if possible by the use of fertilisers. The blocks which were indifferently manured in the past should be inspected with the help of soil classification map and arrangements suggested for manuring the land in those blocks particularly the land which can be raised in point of yield to the standard of first class loam. Efforts should be made to persuade tenants to adopt group farming, and to replace unnecessary bullocks by milch cows. The method for increasing fodder supply should be con-hamlet may be established, if necessary, in a block which is far from or a culvert may have to be made to improve communications. If vacant land is available, proposals may be made for fuel plantation. An esti-the existing inhabited sites, or a depression may halve to be drained, mate for repairing village lanes or for repairing or constructing drinking wells should be made. A multipurpose society should be formed

to give effect to the various suggestions for improvements. A record of the yield of crops should be kept for comparison and a report should be prepared at the end of the year showing the results of the working of the scheme

S. ABDUL HASAN,
President, Court of Wards,
United Provinces

ALLAHABAD :
November, 23, 1946

APPENDIX

Extract from the report of the Special Manager, Court of Wards' Lucknow, regarding results of consolidated farming in village Sarthua in 1353F.

1. According to our plan, crops were raised in all the blocks except in "E" and "H" which were to be left fallow and in block "I" sanai, for green manuring was grown. Early rice was sown in blocks. "A." "D" and "F|1" and late rice in "B", "F|2" and "G" blocks. In block "C" Juar-Arhar was sown. Till the time of writing the Juar-Arhar and the late rice crops had not been cut. The results of cropping in these blocks will, therefore, have to be reported later. Crops had only been cut in blocks "A", "D" and "F|1" in which early rice was sown.

The vital question for determination now is whether there has been definite improvement in agriculture as a result of consolidated farming. It has been admitted by the cultivators that this system of cropping has prevented theft and cattle trespass and has enabled them to utilise better facilities of irrigation. But the main point for determination is whether there has been a definite increase in the yield of the crops.

In order to arrive at a definite conclusion on this point it is essential that an accurate estimate of the yields of the fields included in the blocks be made and compared with the previous outturns,. It is however not possible to determine exactly this yield for we can not weight every maund of the produced grain nor do we have any exact record of the previous outturns of the crops in the village. The only previous data available was that of the Patwari which, as Mr. Wally, Deputy Commissioner, pointed out in one of his inspection note, is absolutely useless for the purpose of this comparison. It might perhaps have been better to have a correct estimation of crops done in the village in one year before the introduction of the consolidated farming, but then inference based on the results of comparison with only one year's figures could also not be considered to be absolutely conclusive. The village admitted that the crop this year was definitely better than ever before and this appeared to us also to be the case so far as last years, crops which we had ourselves seen, were concerned but it is obviously not safe to rely on visual estimates. We were also not sure whether to base our conclusions on crop cutting expriments in which the average crop is selected by the eye. The method suggested for crop estimation by Bowley and Robertson in "A scheme for the Economic census of India of selecting fields mechanically so as to give statistically a random distribution also could not be adopted because a considerable area in the blocks had been especially treated with ammonium sulphate for demonstration purposes and the yields of these fields would have confused the results.

Having, therefore, no better alternative we decided to base our conclusions on a comparison of the yield, in the current kharif of similar fields, such as irrigated fields having the same kind of soil and which

were not demonstration fields, situated within the block. with those not included in the block. For example, Har II was the common class of land in which early rice crop was sown both in scattered fields and in block "A" and Har III was common between block "F|1" and the scattered fields. A few similar fields were selected and their produce weighed. The average produce per bigha was calculated. The results are given below :—

Block	Class of land.	Average yield per bigha in scattered fields	Average yield per bigha in the blocks	Percentage	
				Increase	Decrease
1	2	3	4	5	6
				Per cent	
A	Har II ..	8 3 0	10 36 0	34·3	
F/1	Har III ..	7 20 0	8 25 0	15·0	

It will appear from the above statement that there has been a definite increase in the yield of the fields which are included in the block but while the above figures prove that the yield was increased they, on account of the limited data available so far even the entire kharif crop has not yet been cut. cannot be considered conclusive in so far as the percentage increase in product is concerned. More data would be available by Rabi when further comparisons in yields will be done. These results will be incorporated in the final report of work.

Block "D" in which ammonium sulphate was given as manure consists only Har II plots which had all received canal irrigation. The actual produce per bigha in this block worked out to 13 maunds and 10 seers which is higher than the produce of the fields of the blocks in which ammonium sulphate was not used and, of course, much higher than that of the scattered fields. The following is the comparative statement.

Kind of soil	Average produce in scattered fields	Average produce in fields of block "A"	Average yield of fields of block "D"	Percentage increase in comparison with scattered fields	Percentage increase in comparison with the fields of block "A"
1	2	3	4	5	6
	Mds. Srs.	Mds. Srs.	Mds. Srs.	Per cent.	Per cent.
Har II	8 3	10 36	13 - 10	64·0	21·5

The tenants have very much appreciated the use of ammonium sulphate and this chemical manure is bound to become very popular with them. This manure can, however, only be used in fields which have good facilities of irrigation.

2. In continuation with the figures given above following are figures of kharif and rabi 1353F.:

Serial No.	Name of crop	Name of block	Kind of soil	Average produce per bigha in maunds in blocks	Average produce per bigha in maunds outside the block	Increase
1	2	3	4	5	6	7
	Kharif			Mds. srs.	Mds. srs.	Per cent.
1	Early rise	A	H II	10 36	8 3	34·39
2	Do.	F/1	H III	3 25	7 20	15
3	Late rice	B	H II	9 7	8 0	14·7
4	Do.	B	H II	7 30	6 10	24
5	Do.	G	M III	8 19	7 28	10
6	Do.	F/2	H III	10 15	8 20	22
7	Do.	F/2	H IV	10 7	8 11	23
8	Juar	C	H II	5 3	4 3	25
9	Do.	C	H III	3 25	3 0	20·8
	Rabi					
10	Wheat	E	H I	10 19	9 22	9·68
11	Do.	E	H II	9 28	8 15	15·82
12	Do.	H	H II	10 3	9 0	11·94

In the manner indicated above similar fields were selected, their produce was actually weighed and an average per bigha worked out. It will appear from these figures that the yield has definitely increased and the percentage increase varies from 9.68 per cent. to 34.39 per cent. There is no doubt, therefore, that experiment has been a success and this is further confirmed by the fact that the tenants of the village have made a voluntary application for the continuance of the experiment in this village.

A NOTE ON ITEM NO. 4.

SUBJECT :—Review of the comparative merits of different methods of improved farming practised in the country such as cooperative farming etc.

By N. P. Bhagwat.

The land tenures prevalent in this Province are (i) Rayatwari and (ii) Non-rayatwari. The former predominates the area under it being 44,675,934 acres, *i.e.*, nearly 90 per cent. of the total area of the Province. The total area under non-rayatwari tenure is 3,977,512 acres. Non-rayatwari tenure is divided into various classes and prevails in various parts of the Province as shown below :—

1. *Talukdari.*—(Principally, in Western talukas of Ahmedabad districts, *viz.*, Viramgaon, Dholka, Dhandhuka, Sanand and Gougha. The area under this tenure is 1,466 square miles. There are also Talukdari Estates in Broach, Kaira and Panch Mahals collectorates.

2. *Vanta.*—(More or less in certain villages all over Gujrat north of the river Tapti).

3. *Narwadari.*—(Chiefly met with in Kaira district and in a few villages in the Ahmedabad and Surat districts.

4. *Bhagdari.*—(In Panch Mahals).

5. *Mehwasi.*—(In the area on the Banks of the river Mahi and in Prantij taluka and Modasa Mahal of Ahmedabad district.

6. *Maleki.*—(In Thasra taluka of Kaira district).

7. *Udhad Jamabandi.*—(In Kaira district).

8. *Sarakati.*—Found in few villages all over the Province.

9. *Khoti tenure.*—(In Thana, Kolaba and Ratnagiri districts and Salsette taluka).

10. *Izaft tenure.*—(Scattered over different talukas in the Northern Konkan).

11. *Shilotri tenure.*—(Prevalent along the coast or along the larger creeks).

Holders of lands under non-rayatwari tenure prevailing in Gujarat are generally tenants-at-will. Some of these might have now acquired the status of protected tenants under the provision of Bombay Tenancy Act, 1939. and in respect of the rest the term of tenancy will be hereafter for at least 10 years, according to the provision of the same Act as recently amended.

In this Province, 49 per cent. or a little less than half the number of holdings are below 5 acres and 29 per cent. of the holdings are between 5 and 15 acres. It will be seen that a majority of cultivators are small holders with uneconomic holdings. It is possible for the small holders to combine and pool their resources and avail themselves of the advantages of large-scale farming. It is considered that farming of co-operative farming societies would lead to more profitable and rationalised agriculture instead of the wasteful cultivation of fragments as at present.

Cooperative farming will fall under four categories —

(1) Cooperative Better Farming.

(2) Cooperative Joint Farming.

(3) Cooperative Tenant Farming.

(4) Cooperative Collective Farming.

What form cooperative farming should take would depend upon the basis on which the owners of lands and|or cultivators would agree to pool their resources for joint cultivation of lands.

The lands available for cultivation can be classified into three categories :—

(1) Lands which are at present cultivated by owners or permanent or protected tenants,

(2) Lands belonging to Government or absentee landlords which are under cultivation,

(3) Waste lands belonging to Government or absentee landlords. In the case of lands category (1) Cooperative Joint Farming societies would be a suitable type. In this case, the members of a society work on the pooled lands in accordance with the direction of the elected committee and the manager appointed by it. The ownership of each member in his holding continues and is recognised by the payment of dividend in proportion to the value of the lands. In the case of lands coming under categary (2) and (3), co-operative tentant forming or cooperative collective farming societies could be organised.

In this Province so far about 10 cooperative joint-farming societies of a mixed type have been registered. Majority of them have been registered during the last 2 years. They do not conform to any standard pattern. Their general features are that members have pooled their lands and their livestock etc. and cultivate lands jointly and share profits in certain proportion prescribed in the bye-laws. The members are paid regular wages for the farm work done by them and if any susplus remains after meeting the cost of cultivation and after making allocation to reserve funds ets. it is distributed among the members in proportion to the wages earned by them. The members are paid rents or ownership dividend for contributing the lands to the society for joint cultivation. Government has sanctioned loans at easy rates of interest to some of these societies to enable them to undertake land improvements and provision of irrigation by installation of pumping plants. Government has also provided free services of managers and secretaries to these societies. In the case of two societies registered in Satara district, *viz*, Padali and Bhaktawadi, it is reported that societies suffered heavy losses due to failure of crops on account of excessive rains. In the case of Padali society the total membership is 17 and the total acreage of their lands pooled together comes to 139 acres, 33 gunthas with an assessment of Rs. 441-12-6. Bhaktawadi Cooperative Joint Farming Society has 11 members and the total acreage comes to 115 acres with an assessment of Rs. 284. Both these societies have been given the Government grant of Rs. 1,000 each for purchase of improved types of

agricultural implements and services of a fieldman at Government cost. The Padali society has dug a well on the bank of the river Vasana to a total cost of Rs. 1,136 and has set up thereon an oil engine of 9 H.P. and pumping plant of 3 inches at a total cost of Rs. 2,424 for irrigating 425 plaintain trees and two acres of sugarcane.

The Balkalli Cooperative Joint Farming society in North Kanar district has about 65 members and 200 acres of land under cultivation. 30 members have leased out their lands to the society for purposes of joint cultivation for a period of 10 years. The society intends to put an embankment for which it has approached Government for subsidy.
The Madgumi Cooperative Joint Farming Society in the same district has about 20 members and 30 acres of land under cultivation. The society has taken over 30 acres of minor forest lands which have been divided into plots and given to members for cultivation. Out of 30 acres about 10 acres are under mango and cashewnut cultivation. A compound wall has been built enclosing the whole area in order to prevent damages to crops by wild animals and wandering cattle. The society is striving to bring the remaining 20 acres under cultivation after clearance of thickets. For want of adequate capital, it has not been able to sink a well for water facilities so as to bring the area under intensive cultivation.

It is too early to express any definite opinion about the results of the working of the cooperative farming societies. The farmers are conservative and illiterate and will take some time to make them realise the advantages of cooperative farming. Besides, in the case of societies formed for cultivation of leased lands by backward class cultivators, there is a difficulty of providing security for the loans which they require both for current agriculture and for undertaking land improvements or purchase of costly machinery etc.

Besides these cooperative joint farming societies, there are nearly 76 Better Farming societies working in this Province. These Better Farming societies have been organised with the object of introducing improved methods of farming among members. The aim of these societies is to demonstrate to its members value of good selected seed, improved implements and modern methods of cultivation. The societies provide goods and services to members to enable them to carry on farming on efficient and economic lines. The achievements of these societies in carrying out improvements in lands or by sinking wells and in growing up lands are considerable. These Better Farming societies are given small amount of grants by Government in the initial stages.

The question of developing cooperative farming in this Province has been given serious consideration by Government. A Special Officer was appointed to investigate the suitability of adoption of cooperative, collective, joint or better farming societies and to recommend types of farming societies which would secure optimum production and the most equitable distribution of agricultural profit. The Special Officer has submitted his report to Government and Government has decided to encourage very actively cooperative farming. Government has declared that

it would grant assistance in the form of loans at low rates of interest wherever necessary and subsidies to meet the management expenses in the initial stages. Government has asked the Cooperative Department to take the initiative in carring on prepaganda and organisation of cooperative farming societies and it is hoped that as a result of intensive, which is going to be launched in the near future, good number of cooperative joint farming societies would come into existence.

A NOTE ON THE SCHEME FOR VILLAGE REHABILITATION IN BARODA

By Lt.-Col. C. A. MacLean.

1. *Introduction.*—Investigation regarding the conditions of the agricultural population in certain *mahals* of Baroda State inhabited by *Raniparaj* or aboriginals, chiefly of the Bhil family, had revealed that these simple, ignorant frequently indolent people had been, and were being deprived of their landed property by the more astute and business-minded *sowkhars* or money-landers. The latter are frequently not even State subjects and are invariably absentee landlords : they have acquired considerable tracts of country by their unscruplous methods, but have made no attempt whatever to develop the lands acquired by them, while the original owners have been reduced to the level of bondsmen and serfs. The result is that the utmost possible use is not being made of these lands : the absentee land-lord has no agricultural interests nor instincts while the dispossessed cultivator has no longer the incentive to put forth his best effort in the cause of increased production. These revelations led Government to decide that something drastic had to be done in the interests of the former owners of those lands, so that they might again take their rightful place in the prduction of food and of the raw materials of commerce. But while different forms of tenancy and farming had each its own enthusiastic advocates, no information was available to show which form was really the best from the point of view of the national interest and of the welfare of the individual cultivator himself. Accordingly Baroda State decided on a bold and novel experiment of studying different forms of tenancy and systems on the spot and for this purpose has acquired a large tract of land extending to 4098 bighas (2400 acres) in the Tilakwada mahal. Here peasant proprietorship, tenant farming, and cooperative and collective farming are all being studied.

2. *Details.*—In the first village Khodia, thirty families have been settled and each has been given a compact holding of 20 bighas (one bigha equals 10/17ths of an acre) which will remain indivisible for all time and which cannot be mortagaged or sold except to another member of the same community. The occupier in this case is charged an annual rental equal to five land revenue instalments, one of which is paid to Government as ordinary land revenue, one and a half are paid as interest on the compensation value by Governmant to the *sowkhars*, while the remainder is paid into a central purchase fund which enables the occupier

in time to become the owner of his holding. He is, as it were, buying his land on the instalment system but from the very commencement of the scheme he is recognised as the legal owner of the land which he can farm as he thinks best.

In the second village Pochamba, forty-seven families have been estbalished and the conditions differ from those at Khodia only in that the cultivator is a tenant-at-will. He pays the ordinary single land revenue, farms his holding as he chooses and he can quit it any time he likes.

In the third village Pala, both cooperative and collective farming are being tried out. In the cooperative block, thirty families have been established each with 20 bighas of lands as before, but in this case the holding is not compact as every cultivator has an approximately equal share of the three blocks in which the land is being farmed. It should be noted too that the individual in this case has not the right to cultivate his land as he chooses. The land is actually farmed in three large blocks corresponding to the local rotation adopted and all field boundaries are abolished. The whole village has been organised into a cooperative society and the management of the farm is entrusted to a committee of the society of which the village *patel* or headman is the president. The general cropping scheme is prepared by the Estate Manager and a resident departmental overseer sees that the farm work is carried out as efficiently as possible and in good time. The daily programme of work is arranged by the *patel* and a strict tally is mentioned by him of all the bullock and human labour employed. To allocate values to the different units of production is at present one of the difficulties to be overcome, but the following tentative allocation has been made for the present :—

Bullock powder	4 to 8 units per pair.
Adult male	1 unit.
Adult female	¾ unit.
Boys and girls	½ unit.

At harvest time, the first charge on the produce of the land is in the case of food grains on account of labour employed while in the case of cash crops, the first charge is on account of Government revenue. After these charges have been adjusted, the remainder of the produce is then subdivided into thirty equal portions, one portion going to each house-holder in the village.

In the collective farm which is also at Pala, another community of thirty families has been established with an aggregate of 600 bighas under cultivation. The general system of control and management is identical with what it is in the cooperative farm but with the fundamental difference that no householder has any claim to the produce of any portion of the land. The farm is in possession of the community and in consequence of the communal responsibility for its cultivation, the total harvest after meeting the charges on account of Government revenue is subdivided to each household in proportion to the total units of labour that it supplied towards the cultivation of the crop, This is

the essential difference between the cooperative and the collective farming at the present time.

3. *Results.*—The lands in connection with the scheme were acquired in the hot weather of 1947, and the experiment inaugurated only on the outbreak of the last monsoon. It would, therefore, be permature at this stage to come to any definite conclusions regarding the merits or demerits of any one of the systems under consideration.

At present, however, the *khatedars* or peasant proprietors in Khodia are definitely the superior farmers as one would expect. In the knowledge that they will not be outsted from their holdings they are more enthusiastic in their work and are more inclined to make permanent improvements such as levelling of their fields, putting up brush dams to prevent soil erosion, clearing the borders of their holdings of weeds and undergrowth, and they are also prompt in their attention to all agricultural operation. The *ganolias* or tenants of Pochamba are equally efficient in their normal agricultural operations, but they are not prepared to give the same attention to what might be termed long range work such as land improvement. With this exception, there is little or nothing to choose between the owner-occupier and the tenant farmer.

The experiment in Pala is so novel that the villagers have not yet become accustomed to the idea. The Bhils are inclined to be indolent and it was often a difficult task to get them to turn out to work on land which, they could not cultivate as they pleased. Very satisfactory yields, however, were obtained from the kharif harvest but the people were definitely lazier and less enthusisastic than in Khodia and Pochamba. On the whole, there was little quarrelling in the village, but there was a great amount of petty pilfering. Under ordinary conditions of village life one villager will not steal from a fellow villager, but here, as the crop was communal property, the same inhibition did not exist. Several persons were caught and were dealt with by the committee of management of the society which is constituted as a *panchayat.* Culprits were fined twice the amount stolen for the first offence, there times for the second offence, but persistent thieving will lead to the expulsion of the culprit from the society.

At this stage, the collective farm is showing better results than the cooperative farm, but this is attributed by the Estate Manager not so much to the system as to the personality of the village leaders. In neither system would anything at all be accomplisted were it not for the constant pressure maintained on the management committees by the Estate Manager. The panchayats too have not the necessary vision and drive to direct improvements in the village itself apart from the fields—no attempt has been made so far in making village roads, sinking wells, building a school or any such activities.

C. A. MACLEAN,
Commissioner of Agriculture.

Baroda, 20th February 1949.

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SUBJECT 4.

Cooperative Farming.

There has been no attempt at Co-operative Farming in the Madras Presidency. But we have—

1. *Joint leasing societies.*—Societies have been organized in the Madras Presidency for nearly 25 years now to enable landless labourers belonging to the Depressed Classes to secure cultivated lands of big landlords, and religious institutions—temples and mutts, to be divided among themselves for cultivation by each individual and not by the society as a whole. Some of the societies were called societies for 'Joint Farming'; perhaps because it was intended to purchase cattle and improved implements to be used in turn by members who could not individually purchase them. Actually, little common purchase was done Members, who had no cattle, hired cattle from the nearest village and cultivated independently. Few improvements were effected.

Some societies were formed in the Kistna and Godavari deltas for the cultivation of *Lankas*—islands—in the deltas, which are quite fertile. Members belonged to the Depressed classes and each was assigned by the Government a few acres to cultivate and also given some loan on condition that land would not be alienated and that it would be properly cultivated. But lands were later permitted to the hypothicated to the cooperative society and funds borrowed from it. Societies did remarkably well for a time due to good local leadership. But apart from granting credit, the society did little else. There was no attempt at Cooperative farming.

More recently, so-called 'cultivable' lands have been assigned by the Government to members of the Depressed Classes who had no lands but were good agricultural labourers and also to toddy-tappers, who were thrown out of employment as a result of the introduction of Prohibition. Government gave some aid in the reclamation of these cultivable wastes. A lot of trouble and expense was involved in the clearance of scrub jungle, sinking of wells, laying roads, etc. Each settler was given 5 to 10 acres of land of indifferent quality, which was not enough to maintain a family unless cultivation was intensified by the sinking of a well for which funds were not provided—as is done now for colonies of ex-service men. Where the land is fertile and rainfall sufficient, malaria is rife to which settlers fall easy victims. This has scared away some settlers once for all. Some pay an occasional visit, plough and sow their land and leave it to the care of the brave ones who, hold on, themselves getting re-employed as farm-servants in the neighbourhood. They only come to reap. Situated near forests, wild animals, pigs, boars, etc., make their depredations in the night and eat up the crops. What remains of the crop and the straw are taken away.

2. In the Colonization societies, organized still more recently, land is not assigned away as the private property of the colonist, but he gets the

occupancy right and the right to bequeath it to a preferred heir—with a view to prevent alienation and subdivision. There is a clamour by settlers for full rights of ownership, without which enthuiasm flags—says the Registrar of Co-operative Societies.

In none of the societies above stated, is there any cultivation or harvesting in common, nor ownership of cattle or implements in common. There is no rule enforcing joint purchase of seeds or manures or cattle, though occasionally it is done departmentally. In some societies; efforts have been made to sell jointly the produce of members who have individually raised their crops, but they have little surplus for sale. "Each Colonist prefers to cultivate his land on his own account and to keep for himself the fruits thereof."

II. *Consolidated farming.*—This refers perhaps to the idea favoured by Dr. Radha Kamal Mukherjee and others, whereby small and fragmented holidings might be pooled together for a temporary period for joint cultivation by a group of landholders. These may not be inclined in the first instance to surrender the ownership of any piece of land of their own, but may be persuaded to agree to pool all their bits of land to a society of their own for a scheme of joint cultivation for a period, which would demonstrate the value of joint farming. This scheme was taken up by Mr. S. K. Dey, Collector of Nadia (Bengal), and some societies were formed for the purpose seven years ago. But we find that they havenot done well. The outturn of crops is said to be far less than the average of neighbouring areas. Reasons for failure are : the indifference of members, their unwillingness to work as labourers, inability to engage outside labour, and above all the individualistic outlook, extreme conservation and suspicion (vide *Indian Farming*, October 1945). Co-operators in Madras, who have been watching the experiment, would pause before taking a similar step.

III. *Joint management.*—This refers perhaps to the scheme of Mr. Tarlok Singh I.C.S., which he propounds in his book *poverty and Social change.*. He would have all pieces of land in a village pooled together and restripped in compact holdings each of a size that would engage a family of cultivators and maintain them in moderate comfort. The right of ownership will be respected by a dividend declared based on its values after meeting a number of charges from out of the common pool received in the form of rents from cultivators of the reconstituted holdings. The affairs of the village, besides the management of agriculture, such as, health, sanitation, water-supply and education will also be jointly managed by a body, on which not only cultivators but also owners of land and others resident in the village will have their representatives.

The scheme looks nice on paper, but it is yet to be worked out ; perhaps it is being worked out in the Punjab now among the refugees. We are not sure whether in old settled vilages in madras. landholders will surrender voluntarily their right to cultivate or have their lands cultivated as they like, in return for an unknown and possibly declining dividend.

IV. *Collective farming* of the type found in U.S.S.R. is not found or contemplated in Madras. It is not co-operative farming. It is not voluntary. It gives little option to the landholder or cultivator to join or not. The worker in the collective farm is not free. He can have none of the joy or pride of possession and the stimulus for work associated with *peasant proprietor—though not all small holders* exhibit these qualities in our country. In Madras, for centuries royts have been enjoying the rights of private property in land and undertaking the responsibilities theeof. They cultivate their holdings, small and fragmented, individually though for preparatory cultivation and harvesting they seek the help of neighbours and in turn help with their own services or those of their farm-servants. There are *samudayam* or communal lands, the proceeds of which are utilized for common purposes; but in actual cultivation is entrusted to one individual lessee or more according to the extent of land. There is indeed little tradition of joint cultivation anywhere.

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AGRICULTURAL DEPARTMENT,
MADRAS,
15th December, 1947.

SUI JECT NO. 4.

In view of comparative merits of different methods of improved farming practiced in the country such as Cooperative farming, Collective farming, Joint management, Consolidated farming, Consolidation of holdings etc., with particular reference to improvement in yield of crops and Economic condition of cultivators.

BY P. C. REHEJA.

Reorganisation of Economic Agricultural Producing Units in India based on Prevalent systems of Farming in various countries.

1. GENERAL.

Indian is suffering for the past several years from chronic shortage of food. The *per capita* land available for food production in 1940-41 was estimated at 0.67 acre,(6) and is rapidly shrinking as the population is swelling year by year. With the largest world population of inefficient cattle and other bovine animals the pressure on land is, indeed, very great. The resources of production are under-developed ; the improved methods of crop production are seldom employed ; the peasantry suffers from a heavy burden of debt ; the erosion of soil is in progress at an extremely rapid rate ; the manurial resources are utilised to the minimum ; etc. etc. The social relations between the tenants and landlords, landless labour, absentee landlord, dearth of production capital, absence of an enterprising educated class are further handicaps to the adoption of recommended improved practices. Under these circumstances is it any wonder that even the bounteous nature is unable to assist us out of our difficulties. "The present low yield per acre does not seem to be inherent either in the soil or in the climate" (6). The present level of farming in India is subsistence farming at a low level of production. It, more aptly, can be described as poorland farming. Most of the lands are uneconomically cultivated. The productive agents, namely, the land, the capital, the farm structure and the farmer, that constitute this business are at present ill-utilised and disorganised. Evidently the reorganisation of agriculture on sound and firm basis is urgently called for. The first step in this reorganisation, as it has happened in every other country in the world (12), is the solution of the problems, that directly concern land in relation to the farmer cultivating it, so that in overpopulated India output of food, feed and industrial raw materials per acre is augmented to meet the normal requirements of the Nation and improve the economic condition of cultivators.

II. *Factors in the Choice of Farming System.*

Before discussing the relative merits of the different methods of improved farming it is appropriate to draw attention to the principles and factors which should determine our choice of any system of farming.

1. The first principle governing the choice of the improved farming practice is that it conduces to the gainful employment of the people

engaged in the agricultural industry of the country. In times of depression some of the sub-marginal land which is now being cropped goes out of cultivation and a large proportion of the agricultural labour becomes surplus to the requirements of the industry. Any improved system of organised farming, which can keep up the employment of such labour, would deserve consideration.

The second principle demanding attention is that *per capita* productivity in terms of any quantitative standard such as international units should be high. When agricultural productivity per unit is high it is possible to exchange agricultural commodities at par with the industrial products. It should mean 'an economy of abundance for all'.

3. The third condition which the improved system should satisfy is the successful and immediate application of results of research into practice. The time elapsed between the results achieved and practical use made of them should be as small as possible. Any improved farming practice which retards progress in this direction cannot hold its own under the present conditions of intensive farming. An Indian cultivator though uneducated has considerable experience.

4. Any land reform introduced as a preliminary to the introduction of improved method of farming should be done so in a democratic way. It should involve as little of coercion as possible.

5. The cultivators have a craving for land which is instiable. If possible the improved system of farming should pay due regard to this craving of the cultivator. In Russia despite the ruthless repression exercised on *Kulakas* the land hanger has not subsided. The Russian Government had to allow ½ to 2½ acres of land close to the houses of peasants to satisfy this craving for land.

6. Dr. Ruston (9) in Great Britain estimated that optimum productivity is attained in farms of 75 to 100 acres. In West Bengal, Bhattacharjee (1) estimated that 13 acres farm had an optimum size from the angle of cost of production per acre. In India with varying soil and climatic conditions improved system of farming should take cognizance of this fact. Below optimum size of farms is one of the major organisational weakness in our farm land utilisation.

7. Increase in farming efficiency that might be achieved by reorganisation of the producing units should be capable of withstanding the vicissitude of economic changes and of weathering storms of depression. Small scale enterprises have greater flexibility and usually have stronger resistance to depression.

8. In India capital definitely is in short supply and this insufficiency dominates the entire policy of small area farmers, tenants and share-croppers. Any system of farming adopted must take this fact into account.

9. The factors that constitute the fertility of the land are as important as any others which should guide us in adopting a suitable system of farming. Economic factors contributing to the maintenance of it should receive due consideration (3).

10. Finally, the present is an age of sociological changes. The masses have become class conscious. Peasants and workers refuse to be treated as under-dog. They are clamouring for equal opportunities in life and reasonable decent standard of living. They refuse to be cowed down by the old technique so far in vogue. The whole psychology of the common man has undergone a complete change. In India, in spite of boom in prices, a considerable proportion of the population remains underfed, unclothed and unsheltered. The individual in India is weak educationally, financially and physically. Our main problem, therefore, is to evolve a system which will convert agriculture from a deficit to a surplus economy so as to raise substantially the standard of life of the masses.

Above are some of the important factors which should guide us, in planning and deciding upon any course of action and it is in the light of these facts that we may examine the merits and demerits of various systems of farming in vogue in various countries so as to arrive at a correct appraisal of a system of farming suiting the genius of our cultivating classes.

Agrarian reform has been in the programme of almost all the political organisations so long working for the amelioration of the conditions of masses. Indian National Congress has been working on the basis of decentralised industry although some of its front rank leaders, particularly those with the Socialist outlook, have advocated cooperative farming as a substitute for the present system in vogue. At one time collectivised farming attracted much attention. In recent years the system of joint stock farming is much under discussion. Estate farming has been organised by various bodies and individuals possessing initiative resources, managerial ability and technical knowledge of agricultural industry. Estate farming has principally been linked up with one or the other of the commercial crop cultivation.

III. *Merits of different Systems.*

With the principles governing planned farming and the new concept about soil in relation to agriculture in view (3) let us consider the different systems of farming practiced in various countries, their merits and demerits with particular reference to improvement in the yield of crops and economic condition of the cultivators :—

1. *Cooperative farming.*—The system of cooperative farming has been given trial in various countries. Nowhere it has met with such an unqualified success as in Palestine. Henry A. Wallace has spoken of it as "the most exciting experiment in the world". The factors that have contributed to this success have been the organisations and services behind it. The Palastine Jewish Colonisation Association and the Jewish Agency, both together have been responsible for providing for initial capital and running expenditure. Enormous sums of foreign capital have been spent on purchasing lands and colonising Jews. The land thus purchased and colonised remains the property of Jewish nation.

The other factors which have contributed to holding together of Jews are the ideal of Zionism, socialistic ideals of Russian Jews ; high

proportion of education and intelligent settlers ; inadequacy of the means of production, scarcity of irrigation water and low rainfall ; political zeal,. etc. In India these conditions and factors (i) Social and political and (ii) economic do not exist and cannot be created without definite coercion on the part of the state. It may prove successful where level of literacy is very high and people evince a keen interest in pooling their resources for increased production at low cost. Even in Scandanavian countries where cooperation covers all aspects of rural life cooperative farming has not shown much advance. Small holders' cooperative specialise in sale and purchase of commodities and occupy an important place in the general economy of each of those countries. Cooperative management demands considerable managerial skill and perfect honesty. Enabling laws may be helpful in this direction. But there are few immediate prospects of its adoption in India as in Palestine.

2. *Collective farming.*—It is claimed that by adoption of collective farming the agrarian problems have been very largely solved. The production has been stepped up by 33 per cent. and that the income of the average farmer has gone up by about 4 times in the preceding 20 years. On the other hand impartial socialists and agricultural economists have observed that the productivity *per capita* in terms of International units is not far above India. Colin Clarke (2) has compiled a table to show that relative *per capita* productivity in different countries is as under :—

New Zealand units	U.S.A. units	Denmarks units	G. Britain units	Japan units	Russia units	India units	China units
244	661	642	475	120	88	65	46

'This achievement is in spite of the brutal repression of about 15 years (Masani—6)' Jacny (5) has compared the labour productivity in agriculture in U.S.S.R. and U.S.A. and concludes that productive capacity of American agriculture before the war was about twice that of Russian agriculture and 'thus the output of farm products per person gainfully employed in agriculture was perhaps five times as large in U.S.A. than in U.S.S.R.' Besides, the land hanger of the farmer has not yet been satisfied in spite of the fact that Communist State had to relax this condition and the peasants are allowed to own from ½ acre to 2½ acres of land surrounding their residential buildings. The collective farms are unwieldly and much larger than capable of yielding optimum productivity (4). The actual cultivator gets much less than the tractor workers, managers, etc. It is, therefore that, Doreen Warriner (14) States, 'Measured by any quantitative standard of yield per acre, output per head on the terms of exchange between agricultural and industrial products, the position of peasantry in Eastern Europe in general was better, before the outbreak of war, than the position of the collective farmer in Russia'.

The difference between cooperative farming and consolidated farming is in the fact than in the former case labour and capital resources are also pooled together.

3. *Consolidating farming.*—The objective of consolidated farming is to pool together the agricultural resources of the farmer, who have proprietory rights in the land under a common management. In this the *Trusteeship* of the soil passes on to more enterprising people. A group of selfless workers in such an enterprise may succeed. But more often a few dominate. Since the cohesive forces of law, as in collective or even cooperative farming, is lacking this individual domination raises issues which invariably lead to factions. Besides, the main purpose of consolidated farming is gainful employment of maximum number of persons partaking in the joint effort. If land is scarce and there is reluctance on the part of people, undertaking the joint effort to share their agricultural resources to the full, the enterprise is seldom successful. In the absence of cooperative capital it is usual that the initiative passes out to a few individuals and the very purpose of consolidated farming is defeated. In consolidated farming *Direction*, under congenial economic conditions, can play a progressive role. Since no coercion is involved there is a will to work on the part of the individual for the common good. A group combination of a few farmers is likely to be more successful than a complement of a larger number of people joining the under taking. To a great extent the flexibility of the small scale agricultural enterprise is sacrificed when consolidated farming is practiced. The soil fertility can be kept maintained if manurial resources of the farm are not frittered away. Sociologically consolidated farming offers wide scope provided the democratic spirit dominates the whole enterprise. One authority reports that consolidated farming though practiced in some parts of the U.P., the Punjab and Daccan has not made much progress (10).

4. *Joint Stock Farming.*—Both these deficiencies are made good by joint stock farming.: Here a properly constituted authority tents the land and sublets it to the tenants, most of whom are actual proprietors or their nominees on a short lease basis. A prominent feature of this enterprise is that the profits are shared by the Government, the tenants and the super-landlord (Joint Stock Company) so that capital and labour work in close unison. The economic factors operate in such a manner that optimum yields of crops per acre are realised without destroying soil fertility. The Government and the Company, out of their share, are able to finance research. Close supervision and efficient management contribute very much for the success of enterprise. On the recommendation of the Company, a specific system of crop rotation can be introduced which may consist of food crops, for home consumption, fodder crops for cattle and a commercial crop to pay off the tenancy charges and meet other obligations. In Sudan it is reported to be working very successfully. The farmers are becoming prosperous as the industry has gained stability and is adequately financed at its all stages. The individual farmers have reasonable security of tenure provided they work efficiently. The land holders retain their free-hold right and bequeath their land to their rightful descendents. Further fragmentation has been avoided in view of rights of the joint stock Company in the land. In the new colonisation the Government may initiate some such experiments of

planned land use. Socially desirable family-sized farms may be established. Such a farm would permit intensive efficient use of labour, equipment and managerial ability and give an adequate return per acre to maintain a socially acceptable standard of living (12).

5. *Consolidation of holdings.*—Both fragmentation and reduction in the average size of holdings are in progress. The fragmentation of holdings is the inevitable result of partition proceedings and inheritance under Hindu law or the *shariat* following death. There is no rule or law which forbids subdivision of holdings below a certain limit, except in Central Provinces, and Baroda Cooperative Societies have attempted consolidation of holdings in various provinces with varied success. But so long as subdivision has to go on, any attempt at consolidation holdings is bound to fail. In Europe of the nineteenth century, the reconstructions of the legal fabric of the land system preceded the modernisation both of productive technique and of the business side of farming : nor in the absence of the first, would the last two have been possible, (13). In U.S.A. similar reforms of land tenure have been adopted for reasons stated above. Consolidation of holdings is one of the means for improving the relative productivity of the land. It is not a system of improved farming.

6. *Peasant proprietorship.*—There are several reasons why peasant proprietorship is preferable to any system of group cultivation of land :—

(i) The economy of an overpopulated country demands that bulk of the population should be gainfullp employed. It is the experience of most of the European Countries, which depend more on agriculture than on industries, that small economic agricultural units can 'provide work for two or three times as many persons per unit of area as large undertakings'.

(ii) Agriculture is a very risky industry. It is particularly so where the initial agricultural capital is small. Under such circumstances raising a variety of farm products will prove a better insurance against risks than mass production of Agricultural commodities on a large scale agricultural production. It is for this reason that there is a tendency in Central and Eastern Europe for the land to pass out from the hands of landed gentry into those of small agriculturists. The European Conference of Rural life in 1939 with satisfaction observed, "The formation of a class of peasant proprietors is of fundamental importance in the social and economic organisation of these countries ;......". We have already stated that small scale enterprises have greater flexibility and usually have stronger resistance to depression.

(iii) The creation of peasant proprietorship will satisfy the lust for land of most of the farmers. The Government may so redistribute the land that peasants take charge of socially desirable family-sized farms which would yield return adequate to maintain a socially acceptable level of living. Such farms shall not be sub-divided and shall be non-attach able farm properties.

(iv) In a country like United States of America decentralisation is being advocated as the solution of most of the agrarian economic ills. This view is held by as important a body as the American Farm Bureau Federation (7). It is the essence of centralised production that the wealth and power tends to be concentrated in a few and democracy cannot efficiently work. Farming by peasant proprietors will decentralise agricultural industry and give the greatest possible outlet to the impulse of creation'. The *per capita* productivity in terms of International units in Denmark (=642) is as high as in U.S.A. (=661). The former is a country of small agricultural units while farm units in U.S.A. extend over vast areas.

(v) Reorganisation of agriculture on the basis of peasant proprietorship is bound to step up production. In the Punjab Colonies the average yield of wheat exceeds 18.18 maunds per acre while under indentical conditions of canal irrigation supply it hardly exceeds 12 maunds per acre in the U. P. or the N. W. F. Province. In the former case the land is under the charge of peasant proprietors who are intimately associated with it, while in the latter case most of the lands are worked by tenants, sharecroppers or labours. A stake in the industry means efficient utilization of the skill, intiative, energy and capital resources of the farmer, since it encourages thrift. Thus it will break up the individual inertial which has stood in the way of taking up improvements.

(vi) There is at present much sub-marginal use of land in India. Such fields are seldom inherentry sub-marginal lands. So long as labour can be put in productivity no loss may be anticipated and marginal if not profitable utility of land may be expected. Inpeasant proprietorship ardent labour is an asset which is capable of converting sub-marginal use of land into soil of marginal utility.

(vii) Management of soils considerably tells upon the fertility of the land. A peasant proprietor of a small unit employs all the managerial skill to the management of his land so that fertility of the land suffers in the least. The immediate profit motive at cheap cost seldom enters his consideration. Therefore he adopts sound land use policy with which his soil fertility is conserved and augmental with all the resources at his command. To us it appears that one of the reasons why per acre or *per capita* production by large scale methods of collective farming in Russia has not increased is that the peasant does not feel a stake in his land and therefore erosion of soil fertility is the result which is hampering production per unit.

(viii) Middle peasant classes have been the problem in collectivisation in Russia. Ruthless repression had to be employed to get them into the collectives (5). During the last war when the control was relaxed these peasants tended to appropriate lands to themselves and the Government had to tighten up after the war to bring them back. In the peasant proprietorship this problem will automatically be solved.

(ix) Finally peasant proprietorship will mean even and equitable distribution of agricultural earnings and engender social and political awakening in masses. Present tenancy system is based on competitive profit basis and it continuously improverishes the cultivator and the cultivated land. It will eliminate a functionless class which according to the Farm Tenancy Committee of U.S.A. has been responsible for 'erosion of soil and erosion of society'.

The success of peasant proprietorship, however, depends upon several factors most important of which is the state aid and guidance. There are few agricultural countries in the world with as many great natural agricultural advantages as India. Given capital resources the farmer can raise crops all the year round. Capital advances for productive purposes may be issued through the multipurpose cooperatives which might sell and purchase all the produce of the farmers. In the United Provinces such multipurpose cooperatives have been and are growing very popular amongst the cane growers. All advances for seeds, fertilizers, machinery purchases, etc., are deducted from the cane sales. Where scarcity of water is the limiting factor the Government shall have to lay out irrigation projects. The conservation of soil requires considerable capital outlay. It must be provided by the Government. The Government should provide technical assistance and disseminate knowledge of improved methods of farming through governmental agencies. In every country the progress in agricultural industry has followed the reform of land tenure and in this progress scientific knowledge and technical assistance have played no mean part. Elmhirst states, 'Give me *Direction* Personnel and your millions become a precious asset and not as at present a perpetual nightmare to themselves and the world at large'. It, however, cannot be denied that no organisation to study rural problems exists. Policy of village afforestation for supply of fuel and conservation require urgent attention. The manurial requirements are estimated at 3.5 million tons per annum. Consisting of ammonium sulphate, phosphate and cakes. Even a part of it cannot be met from our current resources. These should be expanded. Export of bones and oil seed should be prohibited and their processing should be gradually passed on to multipurpose cooperatives.

Above all some sort of village democracy should be fostered which can minutely look into the interests of villagers who constitute a village Council or *Panchayat*. It is through this Village Council that socio-economic amelioration of villages is practically possible. All our present plans are drawn up at the top and forced on to the peasantry. It is

no wonder that they prove paper schemes. It is most desirable that the farmers have a voice in the development and administration of such programmes. They will have the advice of all development agencies such as agriculture irrigations ; soil conservation and farm economics ; public health, cooperative, veterinary education, domestic science, etc. etc. The peasants have a fund of experience, are shrewed and have a sympathetic outlook on life. Introduction of village democracy will bring all these faculties into play and conduce to 'better farming' better business and better living'.

IV RESUME.

The acute shortage of food, feeds and industrial raw material is being experienced in the country. Low yields of crops are primarily responsible for total small production of these commodities. Inherently there is nothing wrong with the land and this is in spite of the monsohnish climate of the major portion of the cultivated area in India. Factors other than soil and clima'e appear to be responsible for low net returns per acre. Lack of finance is one such factor. Provision of finance can greatly enhance net returns per acre. But without reorganisation of producing units anticipated increase in efficiency and consequent production that might have resulted by provision of finance, may not be achieved. At present majority of the producing units are worked by tenants or non-cultivating classes. Tenancy systems leads to 'erosion of soil and erosion of society'. Agriculture is a profession which requires as much of patience, skill, aptitude, etc., as any other profession. 'Inefficient enterprise is high cost enterprise'. The tenants and non-cultivating rentiers have a short term interest. It is, therefore, no wonder that 'overwhelming majority of the fields in India produce the irreduceable minimum of crops ; Elmhirst (3) has thus rightly emphasised "Planning in India should be on Sociological basis, covering the whole man and every aspect of his life—neither economic alone nor technical alone........ We may have better seed, better manure and improved plough. But what will these avail if the man behind the plough has not the incentive to put in his best to utilize them. Abolition of Zamindari system alone will not solve the problem.

In the foregoing text we have discussed the essentials of improved farming as a result of the experience gained in various countries of the world in context of our present day agriculture and rural life. The merits and flaws which dominate in the various systems *i.e.*, cooperative. collectivised, consolidated, joint stock, consolidation of holdings and peasant proprietorship farming, have been discussed. Cooperative farming, except in Palestine under the aegis of Palestine Jewish Colonisation Association and Jewish Agency, has nowhere succeeded. Sale and purchase cooperatives have been successful where illteracy is very high. Collectivised farming experiment in Russia has neither solved the problem of middle peasant, raised *per capita* productivity, satisfied the hunger of peasant for land, nor conduced to optimum productivity per acre of land. Therefore, the standard of living of the masses has not improved to any material extent. Consolidated farming is successful where labour shortage is experienced and machinery can be brought into full use.

In India there is over abundance of labour but lack of capital. Joint Stock farming experiment has been successful in Sudan on irrigated colonised lands. It is a combination of peasant proprietorship under joint managemnet of a corporate on and fully aided by the Government of the country. There is scope for its introduction in new colonies which may be brought into being in the great river valley projects under contemplation. Consolidation of holdings corrects an evil in the land tenure system. It is a temporary measure. A permanent measure is the crying need of the day. The one great merit of peasant proprietorship is that by decentralisation the small economic units can provide work for larger number of people than by any system of farming so far evolved. There is greater flexibility of the small scale enterprise which covers up depression risks. With a stake in the land the peasant conserves and augments the soil fertility. The rapacious landlord functionless class of intermediaries are eliminated. The profit motive engenders thrift and sharpens the incentive to increased production. This submarginal land use, so much rampant in the present day economy of this country shall be converted by ardent labour of the peasants into profitable utility of land. It will also mean an even and equitable distribution of agricultural income and social and political awakening amongst the masses. But active state assistance in several directions, as in cooperative, collective, consolidated or joint-stock farming, is essential for creation of socially desirable family-sized farms for the peasants. Along with land reform, establishment of cooperative and village *panchyats*, with the advice of beneficient development state agencies, will electrify rural life. It is surest means of ameliorating the soil and the society in over populated India.

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SUBJECT No. 4.

Review of the comparative merits of different methods of improved farming practised in the country such as Co-operative farming, Collective farming, Consolidated farming, Joint management, Consolidation of holdings etc., with particular reference to improvement in the yield of crops and economic condition of cultivators.

NOTE BY

Sardar Bahadur Sardar Harchand Singh, Commissioner for Agriculture, Patiala.

The consideration of comparative merits of different methods of improved farming as Cooperative farming, Collective farming, Consolidated farming, Joint management and Consolidation of holdings with a view to improve in the yield of crops and economic condition of the cultivators is too *wide* a subject to be considered under one item. With better management and by creating interest in all the workers at the farm, no doubt, all the various methods of farming mentioned above would show better results but all these various methods involves the most important human factor *i.e.*, human nature. Every worker differs from the other in the spirit of cooperation unless there is some stimulous for doing work honestly, an average Indian Farm worker will become slack. For the improvement in this direction, the general sense of duty has to be developed and it will take a long time before any improvement is made in the country as a whole. It is more the necessity that obliges the farm workers to work in cooperation. Of all the subjects mentioned above, consolidation of holdings is most important. Mere persuations on the part of the officials of the department are not enough. The work of consolidation of holdings should be taken seriously and some law should be passed and the land re-allotted in consolidated farms. In this connection, I may also mention the limit of the economic holdings. At present some people have to work on small areas which do not pay. As for the comparative merits of different methods are concerned, the Government should try all these various methods on Government Farms. To force the small land holders against their wishes to adopt cooperative, collective, consolidated for jointly managed farming would not lead good results.

APPENDIX V.

Notes read at the meeting on subject No. 5.

By.—

1. Dr. H. K. Nandi.
2. Dr. E. S. Narayanan.
3. Dr. R. S. Vasudeva and Mr. S. P. Ray Chaudhri.
4. Dr. S. V. Desai.
5. Mr. M. B. Narasingh Rao.
6. Mr. S. V. Doraiswami Ayyar.
7. Mr. R. N. K. Sundram.
8. Lt.-Col. C. A. MacLean.
9. Mr. D. R. Sethi.
10. Mr. M. L. Mehta.
11. Mr. M. C. Bijawat.
12. S. B. Harchand Singh.
13. Dr. B. C. Kundu.
14. Dr. B. B. Mundkur.
15. (Board of Revenue, Madras.)

ORISSA

ITEM 5.—*Measures to be taken from the short-range and long-range point of view to maximise the production of food, particularly of cereals in India, to the maximum extent possible and to suggest 5 years' targets of increase in such production for each unit of administration comprising India.*

BY

DR. H. K. NANDI

DEPUTY DIRECTOR OF AGRICULTURE, ORISSA.

RICE

Rice is the principal crop of India and by far the staple food of the majority of the people. In the year 1945-46 the area under rice in the whole of India was 76 million acres and the total production of cleaned rice in the same year was 292 million tons.

Although there are slight variations in acreage of rice from year to year due to uncertain climatic conditions, yet the production of rice in India even in normal times had never been sufficient to meet its requirements and the deficiency had to be met by importing rice and paddy from Burma, varying from 1½ to 2½ million tons a year. During the last war when Burma fell into the enemy hands in 1942, the source of supplies of rice from that country to India dried up all on a sudden which caused much misery and in Bengal millions of people died of starvation. The situation in regard to the staple food rice after the war has not improved and most of the people are living on a bare subsistance ration in the absence of sufficient quantities of rice or other cereals in the country. The Government of India imported foodgrains from abroad to the tune of 2.3 million tons worth Rs. 100 crores during the last year to make good the shortage to a certain extent.

In the year 1944, the Advisory Board of the Imperial Council of Agricultural Research recommended that to meet the minimum quantity of staple food for the 400 million people in India the production of cereals has to be increated by 10 per cent. *i.e.*, by about five million tons over the normal production. This estimate and the present acute shortage of rice and other cereals in India indicate prominently the precarious position of the country in respect of its staple food requirements.

With the dawn of independence in India in 1947 the country was divided into two States, *viz.*, Dominion of India and Pakistan. As a result of the partition of the country the irrigated wheat and rice producing tracts of West Punjab and Sind and the fertile rice-producing tracts of East Bengal and Sylhet in Assam have been allotted to Pakistan. These areas were surplus in regard to wheat and rice and they used to meet the needs of cereals to a certain extent of some of the deficit provinces of undivided India. The division of the country has been

followed by communal riots necessitating the uprooting of millions of persons from their homes and fertile lands in West Punjab and other Pakistan areas with large-scale exchange of population. These unforseen happenings have greatly accentuated the already existing food difficulties and the shortage of cereals in the Dominion of India is now estimated to be more than six million tons a year. Over and above these the failure of monsoon in some parts, heavy floods in others damage of standing winter paddy crop in Orissa and West Bengal by heavy and unusual rains in December 1947 and all carryover of rice consumed by the end of the year 1947, coupled with the difficulties of obtaining food from outside India, the food position in the country in 1948, particularly in regard to rice and other cereals, will be more critical. I, therefore, suggest the following measures to tackle the serious rice shortage problem in the Dominion of India to make the country self-sufficient and independent of foreign supplies within a period of five years. My suggestions are mainly applicable to Orissa.

The area under rice in Orissa was 5.2 million acres but with the merging of 25 States of Eastern Agency to Orissa the area under rice is now about 8 million acres. About 80 per cent. of the total cultivated area is grown with rice which is the staple food of the people of the Province. Rice is chiefly grown as a rain-fed crop on the same land year after year without a regular rotation and manuring. It is only in small areas of the canal-irrigated tracts with loamy soil that double-cropping of rice lands is practised, *i.e.*, jute followed by rice or rice followed by rabi crops. The practice of growing two crops of rice on the same land in a year or two crops of rice followed by a rabi crop is practically non-existent in Orissa even though soils and climatic conditions are suitable and irrigation facilities are available in some of the areas.

Various classes of rice are grown in Orissa depending mostly on the season, type of soil, level of land, water requirements, life-period, etc. These are mainly classified as (1) Broadcast aus (Behali), (2) Broadcast Aman (Sarad), (3) Transplanted Aman (Sarad), (4) Spring rice (Dalua) and (5) Hill rice. The most important class of rice is Broadcast Aman (Sarad), which covers more than 50 per cent. of the total rice area in the Province.

The measures.—The possible measures which suggest themselves for an immediate increase of rice production are :—

(1) Extension of area under cultivation.

(2) Substitution of rice for jute and other crops.

(3) Double-cropping of rice,

(4) Intensive cultivation.

As regards (1) it may be briefly dismissed as a matter from which immediate and spectacular result cannot be expected. The cultivated area of rice, while it fluctuates with the season, shows little change. In the thickly populated districts, there is no cultivable land except

the village grazing lands which remains uncultivated. In other sparsely populated districts where cultivable waste land is available, problems of malaria scarcity of labour and plough cattle, inaccessibility, poor fertility of land, absence of irrigation and drainage facilities arise. Expansion of limited area under rice will only take place slowly as land is cleared and when irrigation and drainage facilities with big capital outlay by the Government are afforded. This is a long-term project and the first necessity is to make a survey of waste lands noting the specific reasons why the lands remain uncultivated and the actual area suitable for cultivation.

(2) The area under jute in Orissa is only 25,000 acres and a part of this area used to be diverted for rice and other food crops in times of scarcity of food and low price of jute. But with the partition of Bengal, the Indian Dominion has got only 30 per cent. jute land. As practically all the jute mills are located in West Bengal and vested interests are there, it is doubtful whether any appreciable result will be gained by attempted substitution of part of this small jute area in Orissa or other parts of the Dominion of India by rice and other food crops. Such a step is also open to serious economic objections and nothing short of legislative measures to replace jute with rice would have the slightest effect. On the other hand as jute production in the Indian Dominion has to be increased to feed the factories and the price of jute is likely to be higher and the area under jute may increase at the cost of rice. The area under other non-food crops is negligible and there is therefore little scope of increasing rice or other food crops by replacing the non-food crops in Orissa.

(3) Although the rice land in Orissa is one-cropped yet there are areas with irrigation facilities and advantage of early rainfall to grow two crops of rice in the same year one followed by the other. The main principle involved in double-cropping of rice is that the first crop preceding the second or the second crop succeeding the first should be of short duration varieties. Which of these is to be grown first will depend on irrigation facilities, occurrence of rainfall, type of soil and level of land. In the canal irrigated areas where water is available from June to April, rice is grown as a single crop which cover the land from July to November or first part of December. As canal water remains available till April, a second crop of rice of three to four months' duration can be easily raised on the same land with the use of some manures, the cost of which per acre will not be more than Rs. 25. Similarly rice lands on both sides of rivers could be grown with a second rice crop during the period of January to April by power-driven lift irrigation of water from the rivers. There are also vast areas of low-lying marshy and jhil lands in some of the districts, where rice is either not grown during the rainy season due to high water-level or when rice is grown it is damaged by flood. In some of these areas spring rice (Dalua) is grown during the period January to April and the cultivation is confined only to the margins of these lands as the water available in the Central portions cannot be carried very far and this is limiting factor

for further extension of area under this class of rice. If, however, power-driven portable pumping sets run on co-operative lines are provided for extending facilities for irrigation by carrying water from rivers or such big marshy areas or by damming perennial hill streams it will be possible to extend areas under Dalua rice to a great extent immediately which may considerably help in easing the critical rice situation in the coming years.

(4) The only and best method of rapidly and materially increasing the production of rice in Orissa appears to be by intensive cultivation methods from existing rice area which are within the means of the cultivators. The problem of Orissa Agriculture is the problem of small farmers and all improvements in Agriculture must therefore be such as the small farmer can adopt with his limited means and resources. As mentioned already rice is the premier crop in Orissa occupying about 80 per cent. of the cultivated area or about 8 million acres, so even a small increase in the yield per acre over such a vast area will lead to spectacular increase in the production of rice as a result of which the Province may not only become self-sufficient in regard to her normal rice requirement within a period of five years but may also supply a considerable quantity of rice to meet the deficit in other provinces of India.

It is argued that under a system of extensive cultivation a very high average yield cannot be expected. This argument however, does not apply to Japan or other eastern countries, where the rice area is more extensive than in Orissa and still the acre yield is three to four times more than Orissa or India. Forty years back, the average yield of rice per acre in Japan was one-third of the present yield and this remarkable improvement in acre yield has been mainly achieved by the large-scale adoption of improved varieties, improved cultural methods and liberal manuring. It is remarkable to find that 90 per cent. of the rice area in Japan is cropped with improved types and the number of varieties under cultivation is limited to a very few, quite unlike Orissa, where the area under improved types is only 4 per cent. of the total rice area and the number of varieties under general cultivation is more than 1,000. One of the major factors responsible for the present low yield per acre in Orissa is the cultivation of inferior varieties which are mostly mixtures of different types.

(a) *Improved seeds, their multiplication and distribution.*—As rice is the most important crop and staple food of the people of the Province, rightly, therefore, the Agricultural Department since its inception devoted most of its time and attention for the improvement of rice varieties. A very marked success with great economic possibilities has, however, attended this work and several high yielding types of rice, partially independent of the vagaries of climate and possessing earliness, resistance to flood, salinity, diseases and insect pests have been selected and introduced. This line of work has been most suitable to our present comparative poverty and the improvements effected have appealed to the cultivators as its adoption does not require much technical skill and extra expenditure.

The improved types have also undergone rigid statistical tests in the districts for the selection of the best types adapted to the widely differing soil and climatic conditions of the different tracts for large-scale adoption of the types by the cultivators. The results obtained from these tests carried out in the district farms, seed-farms and cultivators' holdings have definitely proved that even under the existing conditions some of these improved types, viz., Dohia, Cuttack Nos. 1 and 2, T. 90, T. 812, T. 1242, T. 442, F.R. 13-A., F.R. 43-B., S.R. 26, B.-etc., which are already popular with the cultivators give on an average three maunds of paddy per acre more over the varieties commonly grown by the cultivators. If we could bring at least 50 per cent. of the rice area under the improved types within 5 years, which could be easily done provided a somewhat elaborate organisation for the multiplication and distribution of reliable seed is set up, the outturn of paddy from this area of 4 million acres would be increased by about 4½ lacs of tons which could go a long way to make up the present acute shortage of rice in India with lasting benefit to the country.

At present the quantity of improved paddy seed produced and distributed is only a fraction of the actual requirement, a vast field, therefore, still remains unexplored. It is only recently that under the auspices of the India Government improved seed multiplication and distribution schemes were taken up on a somewhat extended basis but the result obtained is not commensurate with the money spent. Moreover, there are some inherent defects in these schemes which are standing in the way of getting sufficient quantities of pure and reliable seed of the best adapted varieties for extension among the general body of cultivators. One of the defects is that seeds are distributed without knowing the adaptability of the varieties to be grown under conditions quite different from those under which they are produced and selected. Amongst the improved varieties, there are mainly three grades of rice, *viz.*, coarse, medium and fine and seeds of all these grades are produced for distribution. It is often forgotten that the cultivators as well as middle class people commonly consume coarse rice which in addition to being very high yielder of paddy, yields a high percentage of husked rice of good nutritive value. This drawback in multiplying seeds of medium and fine grades of rice which are comparatively low yielding with less nutritive value and is required to be consumed in much greater quantities to have the same calorific value is a great factor that is standing in the way for extension of area under high yielding varieties, particularly liked by the general body of cultivators. The third defect is that although quite a good number of people have taken to improved paddy varieties, yet such highly improved paddy produced by them is sold out at the very field itself after harvest in order to meet their liabilities of debts and thus passes into the hands of the Mahajans or landowners and become an article of commerce for consumption purpose or the growers of improved paddy varieties do not agree to sell the produce in view of the insecurity of getting rice in the market for their consumption purpose.

The suggested remedies are :—Only seeds of coarse varieties which are high yielding and possess greater nutritive value should be multiplied for growing in areas particularly suited to them and the growers should be compelled to grow the varieties of paddy recommended by the Agricultural Department during this period of acute rice shortage. No subsidy should be given to growers of improved paddy as this leads to corruption and militates against the procurement of really improved seed. As it will take time to establish a large number of seed farms over the whole province to produce the required quantity of pure and improved seed, and establish a permanent agency of seed distribution, the exigencies of the present rice situation in the country demand that all paddy grains to be produced next year by the growers of improved paddy varieties which have established their reputation as high yielders and are popular in the tracts suited to them be procured by the Government Agency under an emergency legislation and stored for seed purposes to be used on a wide scale next year. In exchange of this paddy, Government should supply ordinary paddy to these people to meet their requirements for consumption purpose. As the area under improved paddy varieties at present will be not less than 3 lacs of acre it will not be difficult for a Government Agency to procure a minimum of at least 1 lac of mds. of good seed paddy of the improved varieties which are particularly coarse and popular with the cultivators in the first year. This quantity of paddy would provide seed for at least 2 lacs of acres which should be sown in compact areas, in the second year. At an average rate of multiplication of paddy, seeds sufficient to sow more than 40 lacs of acres in the fourth year would become available. Once the cultivator is convinced of the merits of the improved varieties he would be quick to take to it as he is a shrewed practical man. A well-planned and vigorous policy of seed procurement, multiplication and distribution is the first and most urgent need of the moment. This is the one line of work which is the best, cheapest and surest means under the control of cultivators to increase the yield of rice over the whole country over within the shortest possible time.

Every attempt should, therefore, be made to increase the yield of rice per acre to make the country self-sufficient in respect of this staple food, and liberate land for growing other food and money crops in which Orissa is now deficient and dependent upon outside supply.

(b) *Good quality seed*.—The value of pure seed of high yielding types needs no further discussion as its importance is universally recognised. But it seems that the importance of good quality seed has not received much attention. Experimental evidence from various sources has conclusively proved that an increased yield of 5 per cent. is obtained from seeds which are large, uniform in size, heavy and plump and have come by selection from strong, vigorous and productive plants over those small, ununiform, shrunken and light seeds obtained from unselected and weakplants. The main reason for the superiority of the good quality seed is physiological due to the greater reserve of plant foods which are the first nourishment that the young seedling get for

a vigorous start for growth which enable them to withstand unfavourable climatic conditions better than the weak plants raised from light, shrunken and small seeds.

As seed as a rule is kept from the general crop which is not of the desired quality it is, therefore, necessary to take special care for the production of high quality seed from selected plots by careful culture and manuring. The cultivators should also be advised to adopt the practice of going through the fields before harvest and select the biggest ear-heads of paddy from the best grown plants and keep only the heavy and plumpy grains for seed purpose which is a rational method for improving the quality of seed and consequently the yield of crop.

(c) *Manures and Fertilisers.*—Most of the rice land has lost its virgin fertility on account of continuous cropping for ages without any manure being added to the soil and it has now reached a state of minimum fertility. The hungry land particularly above flood-level, therefore, responds immediately to the use of suitable manures and fertilisers. The manuring of rice lands has been one of the subjects of investigation by the Agricultural Department for a long period and elaborate experiments have been conducted at several places and much is known about the manurial requirements of rice than of any other crop. There is no doubt that the yield of paddy per acre over large areas of rice lands which are not inundated can be increased by 25—50 per cent. by the use of suitable manures of proper quantities but that manuring has not still become a general practice with the growers is due to the following reasons :—(1) Absence of sufficient quantities of manures and fertilisers such as (a) cowdung, (b) oil-cakes, (c) Ammonium Sulphate and (d) Bone-meal, (2) High prices of manures and fertilisers which are preferably used for money crops because of higher return in proportion to rice for the same expenditure incurred and (3) Tenant holding of land on a yearly lease over 50 per cent. of rice area as a result of which the cultivators do not want to avail themselves of methods of manuring which leave the land more fertile than they receive it.

Paddy soils are deficient in Nitrogen and humus and this can be best supplied in the form of organic manures—such as cowdung, oil-cake, compost and green-manure, *i.e.*, growing and ploughing of a green-crop, preferably a leguminous one. This not only adds Nitrogen, the most valuable plant food, to the soil but improves its texture as well. Ammonium sulphate is quite suitable but should be used in combination with organic manures and cowdung is a good all-round manure for rice and the yield of paddy can be increased by 5 mds. per acre by applying well-conserved dung at the rate of 100 mds. to an acre. Much of the cowdung in the village is poor quality as these are not conserved properly and a greater quantity is used as fuel. The quantity of cowdung that can be conserved from each pair of cattle in a year is about 150 mds. but under the present conditions it is doubtful if one-fourth of this quantity is at present conserved. Such a state of affairs can only be rectified by education and propaganda and it is doubtful whether

supplies can be increased immediately for use on rice lands on a large scale.

Different types of oil-cakes are available in the country to a limited extent. The yield of paddy per acre can be increased by 4.5 mds. by applying 5-6 mds. of oil-cake, but they are so expensive and scarce that they are not likely to be of much importance in rice cultivation.

Ammonium sulphate is very efficacious used in combination with organic manures and is available in very limited quantities and is expensive. The yield of paddy per acre can be increased by 4-5 mds. by applying 1½ to 2 mds. of Ammonium sulphate to an acre but from an economic point of view its use for rice crop is not at all popular.

Green-manuring preferably with Dhaincha at the rate of 5—10,000 lbs. of green-leaf per acre results in progressive increase in the yield of paddy which varies from 5-6 mds. of paddy to an acre. Green-manure is, therefore, the cheapest and best of all manures. That it has not still become an universal practice is due to the absence of irrigation facilities making it impossible to raise a green-manure crop on the paddy lands in the dry weather and lack of supply of sufficient seeds of good quality. A heavy leafy growth of Dhaincha crop can be had within a period of 2½ months yielding 15,000-18,000 lbs. of green matter per acre which can be used for manuring 3-4 acres of rice land. The cost of this is only a fraction of the cost of other manures and fertilisers. The practice of green-manuring should, therefore, be encouraged in all irrigated rice areas and in tracts having the advantage of early showers and arrangement should be made for supply of good quality seeds in sufficient quantities in proper time.

The use of compost prepared with home stead rubbish and night soil which are now allowed to run to waste is also another source of readily available manure which can be produced in huge quantities. But no tangible result can be obtained until the Provincial Department of Agriculture take definite and direct steps in their production in different centres and disposal in the fields of the cultivators at free of cost.

During the last 3 years rice position in the country necessitated the adoption on a wide scale of the application of ammonium sulphate and oil-cake as manures for the rice crop as their use offered the most important single means of increasing the acre yield. But inspite of the offer of 50—66⅔ per cent. subsidy by the Central Government for the sale and use of these manures for paddy it is doubtful whether even 10 per cent. of these manures supplied were actually used for paddy as the profit derived from their use was substantial in favour of crops other than paddy. This is evident from the present acute rice scarcity all over India.

As profit is the main consideration with the growers in the use of manures for rice crop and the quantity of manures available in the country is very limited it is suggested that ammonium sulphate or oil-cake be supplied at a very much reduced price at depots in selected rice growing areas, the value of which being recovered in kind as paddy immediately after harvest. The use of these manures for rice should

also be actually supervised by the staff. The Government should also guarantee to purchase a portion of the crop at a fixed price in order to provide against any local fall in price due to difficulties of moving the crop. Government would presumably require this paddy for civil supply. There is no doubt that such a measure will lead to substantial increase in to total production of rice immediately to meet the grave emergency of rice shortage.

(d) *Transplanting versus Broadcasting.*—Unlike other rice growing provinces and countries, where paddy is generally transplanted, over the greater part of Orissa, paddy is sown broadcast even though the conditions are quite suitable for cultivation of Aman (Sarad) paddy as a transplanted crop both in the irrigated and rain-fed areas. Throughout Orissa the seed-rate used for broadcast paddy per acre is usually 40 seers (80 lbs.) and even as much as 60 seers (120 lbs.) in some of the areas, whereas for transplanting one acre of land seedlings obtained from 15 seers of paddy are more than sufficient. Experiments carried out *oll over the Province have definitely proved that a transplanted* crop of paddy will increase the outturn by at least 3 maunds of paddy grain per acre over a broadcast crop. The main reasons for growing paddy as a broadcast crop are shortage of labour and plough cattle as transplanting is a slow and laborious process. If even 50 p r cent. of the paddy area in Orissa is transplanted, the outturn would be increased by about 4½ lakhs of tons of paddy worth approximately six crores of rupees per annum. Moreover, as the quantity of seed paddy required for transplanting is about one third of that of the seed required for the present method of sowing by broadcast, the saving of seed paddy that would be effected by the adoption of transplanting over 50 per cent. of the paddy area, would amount to about 1 lakh of ton of paddy per annum. The introduction and supply of labour saving implements at a nominal cost and compulsory transplanting of paddy wherever the conditions permit would undoubtedly lead to a big increase in the outturn of paddy within 2 to 3 years.

(e) *Control of weeds.*—The conditions under which broadcast rice is grown in Orissa favour the rapid and rank growth of weeds, of which *Panicum crusgalli* and wild rice are considered as serious pest. In the early stages of growth these are often mistaken as rice by inexperienced weeders. These weeds are so troublesome and grow so rapidly that if not eradicated timely they may smother the rice crop. Experiments show that two weedings by the local wooden plough in place of one weeding which is generally practised by the cultivators not only control the weeds effectively but also induce better growth of the crop resulting in increased yield. In the absence of proper weedings, weeds multiply in geometrical progression and become well-established as their grains shatter from the head easily and the wild rice also crosses readily with the cultivated rice rendering it very difficult to eradicate this pest. The importance of high quality seed free from grass, other weed seeds and wild rice is also emphasised for the prevention of weed growth on rice lands and consequently increased yield of rice from the land

(f) *Improved Implements.*—The bullock drawn wooden-plough is the mainstay of Indian Agriculture. With such a plough lands cannot be ploughed till the soil is thoroughly soaked with rain water and the wooden plough does not do anything more than merely scratching the surface soil, portions of land here and there remaining untouched by the plough. There is a great need for the more extensive use of light iron-ploughs suited for bullock draft for the inversion of the soil to an even depth of 5-6 inches for soil aeration, better conservation of water and control of weeds and grasses which grow luxuriantly in paddy lands. There is sufficient evidence available to show that by deep and more efficient ploughing of paddy land with light iron-plough, the yield of paddy per acre can be increased by at least 10 per cent. over the present method of scratching the soil by light wooden-plough. An important factor which has prevented the use of iron-plough on a large-scale has been the absence of suitable arrangement for repairs and replacements of parts.

After the ploughing of paddy lands, harrowing in all directions across the fields is done for 6—8 times. This operation breaks up the soil, which is reduced to a pasty mud and levels the surface soil in addition to cutting and burying the weeds. This worked for the transplanted paddy is spread over a period of about 1½ months, one pair of cattle being employed for an area of 5-6 acres As preparatory cultivation operations are to be completed within the limited period for timely transplanting of the crop, these essential operations are generally skipped due to dearth of labour in the proper season. If the improved harrow which has a number of rotating blades that cuts the weeds and puddles the soil and is found to be an efficient labour saving implement is introduced, an area of 10—12 acres of land can be properly harrowed by one man and a pair of cattle within the same period. The introduction of these simple improved implements with efficient servicing and supply of spare parts are matters of greatest importance for increased productivity of land.

(g) *Irrigation.*—Rice is a semi-aquatic crop. A plentiful and regulated water-supply at certain periods of growth is the first requisite for successful cultivation of rice. The yield of irrigated rice crop per acre is on an average 50 per cent. higher than that of unirrigated crop. But the irrigated rice area in India is not even 5 per cent. of the total cultivated rice area. Rice is mainly grown in India as a rainfed crop, the rainfall varying from 30—250 inches in different regions. Even in regions where the total is adequate it is very unevenly distributed necessitating irrigation for supply of water to the crop at the proper time needed. Although there are big projects of construction of irrigation canals for harnessing of the water of rivers, it is estimated that only a limited area can be supplied with canal water as irrigation by flow is not possible in most of the areas.

Abundant supplies of underground water are usually available in the rainy season and wells capable of supplying water for rice irrigation to supplement the natural rainfall during the periods of drought can

be sunk in nearly all parts of the country. There are many opportunities for this type of development, where water can be obtained by low lifts from wells, streams, roadside ditches, lakes, tanks and rivers either by power-pumps or bullock-driven appliances. It is, therefore, stressed that more attention be paid for construction of both percolation wells and tube-wells for tapping the underground supply of water for irrigation of rice with which production could be increased immediately.

(ii) *Bunds in rice fields.*—The field *bunds* or *ails* are made to demarcate individual plots although the main purpose of these *bunds* it to hold the rain-water or irrigation water on the land and prevent its escape. The holdings of the cultivators are not in compact blocks but are divided into small scattered plots. This fragmentation has gone to such an extent that the individual tiny plots are generally of the size of 1|20th of an acre. The innumerable *bunds* or *ails* dividing the plots have become narrower and narrower making it not only impossible to hold the water so necessary for the growth of the rice but is also throwing out a good deal of arable area out of cultivation and this wastage of land in the aggregate is considerable. Although legislation will be required for consolidation of holdings and prevent their fragmentation, yet steps should be taken immediately to enlighten the cultivators of the numerous advantages of having wider *ails* of 2 feet with 1 foot high and re-building the *ails* every year, to prevent great loss of water from the fields which occur due to seepage and crab-damage to the narrow and unrepaired *ails* and also for checking loss of rich surface soil during the heavy rains. Regular watching of water and *ails* to prevent loss of water during the period of growth of rice is of greatest importance for increasing the yield of rice. This is one of the best ways of conserving the rainfall or irrigation water in the rice fields. In some of these areas blocks of land varying from 10—15 acres should also be surrounded by *bunds* or embankments 5 feet and 2½ feet high fitted with sluice gates for conservation of water and draining the fields of surplus water when required.

(i) *Drainage.*—In areas of heavy rainfall with low-lying areas and numerous rivers, the problem is not one of water conservation but of water-logging. A vast area of the 3 provinces, *viz.*, Assam, West Bengal and Orissa remains completely submerged under water for more than 6 months in a year with water level rising from 5—25 feet during the rainy season. In some of these areas where the rise of water is gradual and does not go beyond 20 feet deep-water paddy is grown, whereas the areas where the level of water exceeds 20 feet and the rise of water is sudden the paddy crop cannot be grown or is invariably damaged. If such areas which are estimated to be about a million acre is reclaimed by drainage cuts or construction of embankments these could be grown with either Aman paddy in the rainy season or spring paddy in the summer. The soil in these low-lying areas is very fertile as the silt from the rivers and top soil of the surrounding lands are washed down and deposited there. The water so necessary for the growth of the crop is also available by natural source in plenty. If

these fertile lands which remain uncultivated are reclaimed by drainage cuts and dykes, and suitable varieties of paddy are grown, the food resources of the country can be increased by at least 3½ lakhs of tons of rice per annum.

As sowing, planting, as well as harvesting of rice crop depend largely upon the condition of the field and heavy clay soils which naturally dry out slowly, drainage is a most important feature. About 10 days before the crop matures the water is to be drained off the fields and the soil allowed to dry. If this is not done and there is also untimely rain at harvest time ripening is uneven and delayed, the crop with the heavy panicle is liable to lodge making it troublesome to harvest and the grain damaged resulting in lowered yield. Provision of thorough drainage is the only solution in preventing this loss of paddy which in aggregate would amount to lakhs of maunds.

Introduction of deep water paddy.—This class of paddy is grown in areas where water during the rainy season collects to as much as 10 to 20 feet. A large lowlying area of the three coastal districts of Orissa, *viz.*, Cuttack, Balasore and Puri known as *pat* lands remains completely submerged under water during the rainy season which gives it the appearance regular lakes. The accumulation of deep water in such areas for a period of more than seven months in a year makes it impossible to grow Kharif paddy crop with the result that such vast areas of very good land which is estimated to be more than two lakhs of acres remains fallow or is grown in a very small part on the margins of lands with *rabi* crops or Dalua paddy in the spring. While deficiency in rain can be combated by taking recourse to irrigation, there seems to be no easy remedies to get rid of the excess water from such deep and low-lying lands. But in the wise and beneficient economy of nature remedies have been provided with which this enemy to cultivation can be successfully tackled. One of these most useful remedies has been found in the deep-water paddy recently introduced to Orissa from Assam, which is admirably adapted to resist the ravages of excessive water, thereby making it possible to bring under paddy cultivation such vast areas of land without any expenditure on reclamation.

The soil in these low-lying areas is heavy clay and owing to the depositions of top-soil from the high lands which is washed down by the running streams and channels that flow from the Western range of mountains, the fertility of the land is very high.

The peculiar characteristics of the deep-water paddy lie in the fact that unlike other classes of paddy, it can stand complete submergence for 10 to 15 days during periods of sudden water rise and has the power to grow and keep pace with the rise of water level always keeping its head above water. The other important characters of this paddy are nodal tillerings which under favourable conditions form ear-heads and formation of nodal roots which absorb nutrients held in solution in the surrounding water.

Work done by the Department of Agriculture, Orissa, with deep water paddy for the last three years has given very promising and successful results. A number of cultivators have already taken to the cultivation of deep-water paddy in their lands with great success which used to remain fallow perpetually to excessive water-logging.

It is suggested that if suitable arrangement is made for the supply of seeds and hand in hand with this, a great deal of propaganda and demonstration work in the direction of tillage, correct time and method of sowing and planting is carried out, this vast area of more than two lakhs of acres of fertile land with an assured water-supply can be reclaimed simply by the cultivation of deep-water paddy, thus adding to the food resources of the country to the extent of 1½ lakhs of tons of paddy every year.

SUBJECT NO. 5.

The possibilities of controlling the rice stem borer, *Schoenobius bipunctifer* Wlk. and the maize stem borer *Chilo zonellus* by means of their natural enemies.

By

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The problem of the maximum production of food from the soil in our country especially in respect of cereals that assumed particular significance during the war years after the tragic famine in Bengal has become even more so in the present period of uneasy transition between war and peace when there is an acute world shortage of food. The slogan 'produce or perish' especially in relation to food is not a mere political catch work but a national urge to increased production to make this country self-sufficient in the matter of its food supplies. Since the Government of India launched the food drive about seven years ago hundreds of thousands of acres of land have been brought under food crops. The increase and change over from cash to food crops and the clearing and bringing in of large areas of virgin lands under the plough have yet by no means reached their maximum limit and are bound to increase much further as seasons pass by. But it is not possible to reach our national goal of self sufficiency by merely increasing the area of cultivation. There are other important factors such as better seed, application of the right type of manure, preservation and control of plant disease and last but not the least the reduction to a minimum by modern control methods the damage caused by the insect pests. The last factor is an important factor, for the damage caused by insect pests can some times be very serious. Insects as is well known multiply in geometrical progression and if even only a few females are left undetected or neglected in the field, they will multiply in thousands in a relatively short period

and produce results that can only be described as disastrous. An insect assumes the status of a pest in relation to its environment and one of the chief factors governing this environment is an unlimited supply of food. Many insects that are no more than harmless scavangers in their primeval state have become pests of first class importance when their potentialities to reproduce and increase have been rendered possible by a generous food supply. As Professor Munro observes "the growing of crops in large but compact areas and the cultivation of pure crops of only one plant are wholly artificial phenomena. They afford the insect an uninterrupted nd large supply of its host plant and thereby favour their increase. An insect living on wild Solananceae finds it host plants scattered and mixed with plants which have no interest for it, but the same insect arriving in a potato field finds an unlimited and uninterrupted food supply. When its numbers increase, dispersal is no longer necessary to ensure adequate feeding or breeding ground. The risks which such a dispersal, necessary when the insect is living in a natural environment, entails are avoided in the potato field, and by the mere act of cultivating his crops as pure crops extending over large areas, man favours insect attacks on these crops".

It is proposed to discuss in this short note an aspect of control that will reduce the damage caused by two serious insect pests of rice and maize, two of the important cereal crops grown in our country. Those who have seen rice cultivation in this country extending over miles and miles as far as the eyes could reach in the low lying plains of Western Bengal, the delta tracts of Godavari and Krishna in the South on the fertile coastal areas of Tanjore can vividly imagine what havoc a pest is capable of doing when once it gets an unrestricted entry. Rice is a very important cereal crop in our country and the staple food of millions. Maize is another important cereal crop and though not as important as rice or grown in such a large continuous belt as rice is nevertheless a valuable economic crop. The imperative need for reducing the damage to the eminimum caused by insect and thus increase the yield from a unit area needs no emphasis.

Schoenobiu binunctifer Wlk. the paddy stem borer is a very serious pest of rice and is distributed throughout the tropical regions of South East Asia. The pest has been observed to do damage in all the rice growing areas of India. It belongs to the order Lepidoptera and the family *Pyralidae.* The broad outlines of the life history of the pest are well known. The female moth lays an average 60—100 eggs on the paddy leaf often towards the tips and covers them with buff coloured hairs. The eggs hatch out into larva that tunnel into the stem and destroys the central shoot in young plant and ear heads in mature plants. When full fed the caterpillar is about an inch or an inch and a quarter in length and is pale yellowish in colour. It pupates within the stem in a transparent silken cocoon and the adult moth emerges through a hole made by the caterpillar before pupating.

Chilo zonellus the maize stem borer is a very serious pest of maize and the damage caused in the early stages of the crop can often times be very serious. Some times the whole field may be wiped out. The

pest is distributed throughout India wherever maize is grown. It belongs to the order Lepidoptera and family Pyralidae. The female moth lays scale like overlapping clusters of eggs from 10-30 on the under surface of leaves near the mid rib. The young leave that hatch out bore into the stem and destroy the control shoot. Pupation takes place within the stem. At the end of the pupation period the moth emerges.

Of the six principal methods of insect control namely the mechanical, the cultural the physical, chemical, the biological and the legislative, the biological control of insect pests some times deescribed as the biological basis of insect control has attracted a good deal of attention within recent year. The almost spectacular success that attends the introduction of the lady bird beetle, *Rodolia cardinalis* from Australia to California to subjugate the cottony cushion scale, *Iccrya purchasi* that was threating the horticultural industry of that state with extinction, which has been described by Howard as a "Classic an applied Entomology and Horticultural" and the equally astonishing successes that attended the introduction into the Hawaiian Islands of two chalcid egg parasites, *Paranagrus optabilis* from Queensland and Ootetrastichus beatues from Fiji to control the sugarcane leaf hopper, *Perkinsiella saccharicida* Kirk and the Tachinid parasites Pychomia remota into the Fiji Island for the control of the Levuana caterpillar *Levuana iridescens* that was causing serious damage to cocoanut plantations have greatly added to the popularity of the method. The romance of the biological control of the prickly pear Opuntia dillenii by the melly bug, *Dactylopius tomentosus* in South India is too well known to need any detailed comment. The biological method is more fundamental in its approach and when successful is the economic method. As Thompson observes the mechanical and chemical method of control have to be repeated year after year and the cost is often excessive and the technical difficulties involved enormous. Professor Munro concurs with Thompson with this view and observes "Insecticides as a class are palliative measures bringing about a more or less rapid decrease of the insect during the first or second seasons of its abundance. Mechanical measures, such as fly traps, grease bands placed round trees to entrap willingless moths or wandering caterpillars or bait traps designed to attract moths, weevils, and 'wireworms,' are also still largely employed merely as palliative measures designed to secure relief during severe attacks".

Now let us examine if we can apply the biological method of control in the case of the rice stem borer and the maize stem borer. The eggs of Schoenobues bipunctifer are parasitised in nature by three well known parasites. These are :—

1. *Tetrastichus schoenobi,*
2. *Phanurus beneficiens,*
3. *Trichogramma evanescens minutum.*

The last named parasite *Trichogramma evanescens minutum* is bred in million in various centres in India for the control of the sugarcane stem borer *Argyria sticticraspis*. We can liberate these parasites in

the field against Schoenopius and see if can get a measure of control. As regards Tetrasticlus and Phanurus, it is suggested that these parasites be conserved in the field in suitable cages so that the parasites population may increase in relation to the pest population. At the same time we have to make laboratory studies for finding out suitable alternate hosts for breeding *Tetrasticus* and *Phanurus* in millions. From laboratory studies carried out in the Indian Agricultural Research Institute, it has been found out that *Trichogramma evanescens minutum Riley* readily parasiteses the eggs of the maize stem borer Chilo zonellus. We liberated parasites in the field at the rate of 16,000 parasites per acre as the attack by the borer was very serious and obtained about 80 per cent. of parasitisation in the field and a very fair measure of control. The experiment will be repeated but the results obtained so far are very encouraging.

As has been emphasised above, the biological method of control is more fundamental in its approach and if we succeed in controlling these two pests by means of their natural enemies we would have written another chapter in the story of applied entomology in this country.

SUBJECT NO. 6.

Consequent on the division of the country, to consider measures to be taken from the short range and long range point of view to maximise the production of food. particularly cereals in India, so as to reduce her dependence on imports to the minimum extent possible, and to suggest five year target to increase such production for such Unit.

By

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INTRODUCTION.

The division of India in August, 1947 has made the problem of the food supply extremely complicated and we have, therefore, to critically examine the means by which the production can be increased so as to meet our requirements. In the Indian Union now the immediate problem is the feeding of 317.696 million of people whereas the land area under food grains and potatoes is about 164,964,252 and 393,800 acres respectively. Taking 1 lb. as average of food grains per head per day as the normal requirement about 51.8 million tons of grain are required to feed the present population in the Indian Union. The effect of the increase of population which is estimated at nearly 5 million every year

on the food situation also requires to be borne in mind. The average production of food grains in the Indian Union is estimated at about 41.2 million tons. Taking into consideration that 4 per cent. of the food grains are reserved for seed purposes and loss in storage about 5 per cent., the total shortage on these accounts is 3.7 million tons. Out of a total 41.2 million tons produced, only 37.5 million tons are therefore actually available for food purposes, and considering our requirement at 51.8 million tons, we are to begin with facing a deficit of about 14.3 million tons.

The world food requirements in 1950 assuming 25 per cent. increase in world population, has been estimated by F.A.O. It has been suggested that the production of cereals and pulses must be raised by 21 per cent. and 80 per cent. respectively to meet the normal food requirements. From the approximate optimum requirements of food for an adult, particularly the major cereals, it is necessary that the production may be considerably stepped up if the food requirements of the people in the Indian Union have to be adequately met. Efficiency in production of agricultural crops in India is at a very low level in comparison to other countries, and great efforts require to be made to raise the level. As much as possible of the vast area of 86,639,748 acres lying as waste land as well as the cultivable land lying fallow for the lack of population must be brought under cultivation without further delay. The yield of food grains for every acre in India can be increased by about 20 per cent. by the protection of crops against diseases and pests and by the introduction of high yielding diseases resistant varieties. This only would enable us to meet the deficit of 8.24 million tons of cereals. The average yield per acre of cereals in the Indian Union is very lower than that of most of the other countries.

CEREALS AND PULSES

The average yield of rice per acre in our country is about 763 lbs., while countries like Egypt, Japan and Italy have an average yield between 2,688 and 4,256 lbs. The rice crop suffers considerably from 'Helminthosporium disease and from *stem rot*'. Helminthosporium disease was partly responsible for Bengal Famine in 1942. In some districts this disease appeared to be the chief cause of the failure of the crop. The primary infection can be controlled by the hot water treatment. Also Diphenyl vapours appreciably reduce the wastage of paddy due to infection with *Helminthosporium*.

An approximate idea of the loss due to stem rot (*Sclerotium oryzae*) in the Punjab has been estimated at three-fourths of the entire crop in certain seasons and reduction in yield. 5-15 per cent. occurs almost every year. The extent of damage due to this disease in other parts of the country is not known. *Basmati* and *Mushkan* groups of rice have been found to be most resistant to the disease in Punjab. In addition to burning the diseased stubble, construction of strong and high bunds round the infected plots and proper irrigation and aeration of the soil have been found effective in checking the disease. The blast disease of paddy also requires special mention as it is responsible for very heavy losses.

The loss due to this disease both in Madras and Bombay has been reported to be serious. It is reported from Supa Petha in Kanara district of Bombay which has about 8,000 acres under paddy that the loss due to the blast disease recentry has been 370 lbs. per acre, so that the loss to this small area, alone the Government rates is Rs. 3,20,000. No suitable measures of control of this disease are so far known and necessary investigations along these lines have been taken in hand but the work requires to be speeded up.

The average yield of wheat in India is estimated at 642 lbs. per acre as compared to 1,878 lbs. and 1,728 lbs. in Egypt and Japan respectively. The losses in yield due to rust and loose smut of wheat are very considerable from year to year and are in certain years responsible for the entire failure of crop. Measures to control the rust epidemics require to be investigated and work on the evolution of rust resistant varieties requires to be extended. Loose smut of wheat has been successfully controlled by the solar energy method which has proved great success both in the Punjab and Bihar. In addition certain varieties of wheat evolved at the I.A.R.I. have shown considerable resistance to the disease.

The losses due to the smuts of Jowar and Oats are also serious. Grain smut of jowar has been controlled by the use of sulphur dust of a high degree of fineness. The modified dry spray method of applying formaldehyde to the smutty grain which is employed at the I.A.R.I. for controlling covered and loose smuts of oats has been found to be of great practical value.

Helminthosporium disease of barley which appears in severe form almost every year can be practically controlled by seed treatment with mercuric compound. The disease cannot be completely controlled by seed treatment, as the organism lives in the soil and is present on greasses and other hosts. It is therefore essential to develop resistant varieties. Gram blight and wilt of pulses too are responsible for tremendous losses to be crop every year. Financial losses incurred due to blight of gram in the Punjab alone have been estimated at about three to four crores of rupees annually. In certain localities destruction of gram crop by the blight and wilt diseases occurred for many years successively with the result that gram which is staple food of people in these areas was not obtainable and caused famine conditions. Type F8 has been found to highly resistant to the blight disease, and wilt disease can be kept under check by adjusting the sowing time. Varieties resistant to prgeon-pea wilt, a very destructive disease, have been selected at the I.A.R.I.

POTATO

Potato, one of the important food crops, is produced abundantly in other countries, and its production exceeds that of wheat and rice combined, which are the other main food crops. The area under potatoes in India is much smaller in comparison to other countries and is estimated at less than one per cent. of the world's acreage. The quantity produced in this country is estimated to be about 1.57 million tons which is highly insufficient, as India was importing before the war potatoes

worth about 30 lakhs of rupees from other countries so much so that certain parts were wholly dependent on foreign potato. A regular flow of potatœs for table purposes cannot be kept up without a constant source of seed potatoes of high quality and some system of maintaining freedom from disease on a large scale so that the deterioration does not exceed the rate at which healthy material can be distributed.

On an average about 109 maunds of potatoes per acre are produced in India as against 224 maunds in Belgium and 183 maunds in the United Kingdom. Compared with other important potato growing countries of the world, the yield per acre in India stands at the bottom.

The chief cause of lower yield are the virus diseases. The incidence of these diseases is very heavy in most of the potato growing areas in the country. Losses to the crop due to virus disease alone in the U.P. Bihar, West Bengal and East Punjab have been estimated at the I.A.R.I. and vary roughly between 10 and 22 per cent. The total loss in yield has been estimated at about 0.22 million tons annually in these areas alone and the financial loss incurred amounts to roughly Rs. 58,700,000 per annum. The total loss in the Indian Union, considering the area under potato, masking of disease symptoms and the late blight disease of potatoes, would actually be much higher.

The diseases are mostly carried in the seed tubers and steps have, therefore to be taken to produce disease-free seed stocks and distribute the same to cultivators. From statistical reports available in Canada it is obvious that the crop raised from certified disease-free potatoes yield double the quantity of tubers. While the raising of seeds which are completely free from disease is a long drawn process and will involve work over a number of years, as an immediate measure, an elaborate scheme to raise seeds comparatively, though not wholly, free from diseases must be launched on a country-wide scale. The use of such seeds will increase the yield of potatoes per acre by about 30 per cent. and thereby the total quantity of available food supply in the country The question of supplying disease-free potato seeds has, therefore, an important bearing on increased food production. As an experimental measure, a small scheme in this connection has already been carried out at the I.A.R.I. for three years and the performance of the seed distributed under the scheme was extremely satisfactory regarding stand of the crop, disease incidence at the yield.

The yields according to the reports of the U.P. Department of Agriculture average 233 maunds per acre as against approximately 175 maunds obtained by the cultivators from the crop raised from the seeds received from other sources. The yield in the following year was 200 maunds as against 135 maunds from the seeds obtained by the growers from other sources. The disease incidence in the crop raised from seeds supplied under the scheme varied from 2 to 3 per cent. as against 40 to 80 per cent. in the crop raised from seed secured from other sources.

The most satisfactory means of achieving the object would be to improve the quality of seed raised in the important seed centres in the first instance and provision of adequated facilities to the growers for storage of seed in the cold stores. If this scheme is worked in co-operation with the progressive growers in each administrative unit, the cost of running the scheme would not be high, but if the Government decide to purchase the seed so produced and preserved it in the cold stores at their own cost, the expenditure towards the scheme can be conveniently met from the returns under the scheme.

Measures to step up production.—The losses incurred due to various disease that attack the crops in India have not yet been accurately determined and there are no reliable figures available for this purpose. The only figures available are from U.S.A. the losses in yield caused by the common diseases are recorded for individual States and for the whole of the U.S.A. The average loss during 1930-39 caused in the U.S.A. by plant diseases in twelve different crops which are important in India vary from 6 per cent. to 20 per cent. being highest in potatoes. The average losses in wheat and maize are 10 and 12 per cent. respectively We have in India very large number of diseases which cause great losses to our crops. It is essential that we have accurate information on the destructiveness and distribution of the diseases so that first attention is directed to the most important problems and to guide effective programme for the control of diseases by their exclusion etc. The loss to the individual grower also requires to be considered with a view to determine whether the expense involved in contolling a disease is justified. Most up to date infomation on the progress of epidemics is of great assistance in directing the growers practices in the immediate future, and reduces monetary losses because of low prices or high crop-yield predictions. It is therefore, indispensable that both pathologists and growers be regularly informed of the distribution and severity of different plant diseases. This information can obtained by regular plant disease surveys which should be undertaken without further delay.

There are certain disease *e.g.*, loose smut of wheat, grain smut of jowar, covered and loose smuts of oats, gram blight and potato viruses etc., for the prevention of which definite control measures have been established beyond doubt. There is no reason why they should not be enforced for adoption by farmers to eliminate them and save the food crops from heavy losses. What is required is adequate staff or legislation.

The measures both short range and long range to increase production are summed up below :—

Short-range.

1. Certification and. multiplication of disease-free seed stocks of cereals in cooperation with progressive powers.
2. Testing out of improved varieties iin different tracts with a view to finding out the most suitable varieties..

3. Production and distribution of partially disease-free seed potatoes.
4. Seed treatment and protection of the growing crop against diseases.
5. Determination of the losses due to important diseases. A survey requires to be immediately taken up as little reliable data are available.
6. Provision of suitable seed-stores for cereals and potatoes.

Long-range.

1. Production of high yielding disease-resistant varieties suitable for different tracts.
2. Seed Certification of potatoes.
3. Investigation of simple and effective control measures of important diseases of food crops.

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ITEM NO. 5.

Suggestions for increased production of food in India.

(NOTE BY DR. S. V. DESAI).

Due to a variety of reasons, the level of average production in India per acre is low in the case of most crops. 4/5 of the total cultivated area are dependent purely on rainfall for the success of their crops. In much of the area the rainfall is precarious or badly distributed. The

cultivator himself by reason of handicaps or ignorance fails to make the best use of the land, the rainfall or the irrigation. Manure is either used inadequately or not used at all. The improved varieties of seed are not available. Pest and diseases of crops are allowed to go unchecked. Weeds flourish uncontrolled, and in sloping land, the rich top soil is eroded and carried away through failure to control rainfall and surface water by bunding and other means.

2. The cultivator can directly increase the production by paying proper attention to these problems. Similarly a poor return is obtained from his livestock through inadequate feeding, indiscriminate breeding, indifferent management, and through ravages from disease, the net output per animal in India is one of the lowest in the world. The increase in the population and decrease in fertile land are as great a threat of human society and atomic Bomb.

3. I propose to limit my discource to the increase in production that could be brought about by adopting a new outlook on the manuring of the land to maximise the production.

4. The Soils of India have a low reserve of essential plant nutrients, and; therefore, a heavy application of manure is necessary to obtain appreciable increase in yields as part of manures has to be used up to neutralize the depleted reserve. It is, therefore, essential to manure a small plot heavily than a large plot lightly. The immediate return obtained by heavy manuring far exceed that obtained by using the same measure in lighter doses. The possibility of remedying the inadequacy of manure by giving a full or an excessive dose of manures to smaller areas by rotation requires to be brought to the notice of the cultivators.

5. Every crop that is removed from the land depletes the soil of the three most important plant food ingredients, namely, nitrogen, phosphorous and potash. An average good crop removes about 40 lbs. of nitrogen, 20 lbs. of phosphoric acid, 40 lbs. of potash per acre and unless these ingredients are replaced the fetility of the soil must naturally diminish. It has been recognised that extensive tracts of the country are now at a stage of minimum fertility. This would indicate how vital is the question of adequate manuring in the country.

6. The value of F.Y.M. lies not only in the nitrogen it supplies but also in the organic matter it adds to the soil. The production of dung and urine in India is computed to be equivalent to one million ton of nitrogen. It has been estimated that 40 per cent. of what is produced is used as manure and the rest is either burnt or wasted due to difficulties of collection.

7. In India the use of cowdung as fuel has been long deplored but concerted action against this has not yet been taken, the main difficulty being the supply of alternative cheap fuel. Recent experiments have shown that cowdung and litter can be used to produce fuel gas and at the same time yield highly efficient manure if fermentation is carried out in anaerobic tanks and the gasses evolved are collected. This process if adopted would enrich the soil by half a million ton of nitrogen per

annum and supply cheap fuel at the same time. This would lead to a permanent improvement of the land, as well as of the sanitary and economic condition of the villagers by provision of the manure, fuel and a cheap source of power in every unit area. The capital cost of the installation could be easily liquidated in fifteen years' time. The process is very hygienic as fly breeding is absolutely controlled. The production of bulky organic manures where it can be locally used up offers a very easy solution of the transport difficulties.

8. The local methods of preparing F.Y.M. are highly wasteful and considerable proportion of the available nitrogen is lost during the preparation and application of the manure.

9. A great stress is already being laid on the preparation of compost from town and other agricultural wastes for improving the productive capacity of the soil. All methods of production require manual labour and proper supervision to prepare compost of good quality. The manures so produced have been found to be of good value.

10. Poudrette or night soil manure is not utilised in India with as much care and zeal or to that extent as in China and sewage utilization is still disliked by the farmer class. Experimental evidence has shown that chance of soil sickness under tropical conditions are remote if the sewage is used judicially.

11. Green manuring is often recommended. It succeeds when the soil requires only nitrogen and where sufficient amount of moisture is maintained in the soil during the period of its decomposition either by adequate rainfall or by irrigation. As no other mineral matter besides what was present in the soil is added to increase the reserve of phosphorous and potash the practice of green manuring can only add nitrogen to the soil by fixation from the atmosphere and can only benefit if the soil has sufficient reserves of phosphorous and potash.

12. The green manure has to be grown on a field, which can by adequate use of nitrogen manure produce some other good crop during the period, and, therefore, green manuring can be practiced only losing a crop. It would, therefore, be apparent that if nitrogenous manures are available the practice of green manuring is far from advantageous. But as there is a dearth of nitrogenous manures the practice of green manuring has to be utilized to enrich the soils. It has been established that the leaves of the green manure crop contain most of the nitrogen and produce the highest increase in yield as compared to other tissues of the crop and as such the question of manuring with leaves while utilizing the stems for the production of fibre, as in the case of sunhemp, requires to be considered seriously.

13. Oil cakes are another important source of manure. They also have an alternative use. But some oil-cakes like castor, and mahua which are non-edible form a good source of nitrogen. Mahua cake requires to be decomposed before application to the soil and a process for the purpose has been evolved to show how benefit can be obtained by utilizing this cake.

14. Researches conducted in India and abroad have established that legumes show a great response to application of phosphates and that application of P_2O_5 in large amounts to legumes not only benefits the crop but it builds up soil fertility resulting in increased yield of the succeeding crops. This treatment not only fixes atmospheric nitrogen to supplement the nitrogen deficiency but also mobilizes the mineral requirements of the crop in easily available form.

15. The practice of green manuring to increase crop yields and to supplement the soil nitrogen has much greater value if the crop is fertilized with phosphorous. The value of green manuring which is some times found doubtful is the results of using the practice on a soil deficient in phosphates or other minerals. It is not fully realized that the practice of green manuring can only add nitrogen to the soil and the importance of other mineral deficiencies as a limiting factor in Indian Agriculture is still considered secondary.

16. The use of F.Y.M. and other organic manures has a strong appeal to the practical farmers and the easy availability and familiarity with the manures is the major factor of its hold on the farmers. The artificial fertilizers which in our country have been synonymous with nitrogenous fertilizers has not given very hopeful results when used by themselves but when used in conjunction with organic manures like F.Y.M. oil cakes or compost the beneficial effects have been more common. But we have still to realize the most beneficial effect which arises from manuring legumes with superphosphates.

17. A microbiological method has been evolved at the I.A.R.I. which can give a very good indication of the mineral requirement of the soil within a short time and if the manurial deficiency is made good by balanced manuring an increase in yields is sure to results.

18. Even without any chemical or Bacteriological or field trials it is possible to suggest manuring schedules by a competent agricultural officer if he realizes that for increased production the mineral deficiency other than nitrogen be attended to. The nitrogen could be made good by fixation either by a Legume in the rotation or by a symbiotic nitrogen fixation. The nitrogen so added to the soil is much more valuable to the crops as it is retained and not lost as is the case when it is applied as a fertilizer. It is very significant that nitrogen content of plots manured with phosphate is much higher than those of plots manured with nitrogen and the nitrogen status of the soil could be maintained high only if the phosphate and other mineral status is maintained at a proper level. Thus the nitrogen deficiency is a secondary deficiency and if this is recognized as a fundamental basis for all advisory work the fertility status of the soil could be increased beyond the most optimistic expectation.

19. It would not be out of place to mention that the enormous and undreamt of increases in yield now being obtained in U.S.A. are largely due to the application of mineral fertilizers mainly other than the nitrogen, (phosphates and limes) and growing a legume fodder to bring about the right type of humus formation with balanced minerals and nitrogen to meet the needs of cereal crops.

20. Our soils have been highly depleted of Phosphorus which has brought in its wake nitrogen dificiency and they have been so depleted that a single manurial application is not able to bring its productive power to a high pitch, what we need is a treatment of rejuvenation for our soils and how this can be accomplished has been recently shown by the work of Mr. Parr who obtained very high yields of cereals by manuring berseem with phosphates and improving the mineral and nitrogen status of the soil. It may be mentioned that winter legumes have been found to be much more effective in bringing about soil rejuvenation than Kharif legumes and fodder legumes are better than legumes grown for seeds. If by any treatment a very good fodder crop of legumes specially winter legumes is obtained, the soil gains in fertility and it would ensure good yields of the following crops. Thus what we need is a suitable rotation including a winter legume (preferably a fodder legume) and a soil treatment to supplement all deficient minerals to bring about the good growth of this legume. If we can achieve this by whatever treatment locally suitable the crop yields of the following cereals could be increased not a meagre 10 or 20 per cent. but by hundred per cent. The crying need of the country is to replenish the soil phosphates. It has been recognized now that phosphate is the bottle neck of worlds' hunger. The low yields in India is the direct result of the neglect to replenish the soil phosphates which has resulted in the soil deterioration. The organic manures contain to some extent this phosphorus and the beneficial effects specially ascribed to the organic manures could be attributed to the supply of phosphorus in an organic form which becomes available to the crops.

21. The whole outlook on the fundamental conceptions of soil fertility requires a radical change. The quality of humus produced by balanced mineral nutrition is very important in increasing the soil fertility. With the same amount of low quality humus, the soil may be barren. The quality of the humus depends on the mineral status of the soil and not on the amount of organic matter added to it.

22. The crops raised with phosphate manuring in India contain larger percentages of phosphate and nitrogen than those not so manured.

23. It is known that the nutritive value of fodder and feeds for animals is improved as phosphate content increases. The poor type of indigenous cattle in area deficient in phosphates is a problem in India which has not yet been visualized.

24. By the systematic use of phosphate with the appropriate legumes either as fodder crops, green manures or pulse crops, Indian crop production can be very considerably improved not only quantitatively but also qualitatively. The advantages of these improvements will be shared by the domesticated animals. The method ensures moreover not only higher production of phosphate rich protein fodders but increased yields of all crop byeproducts which make up animal feed. As the means whereby the phosphate is kept in circulation, farm animals play a part the importance of which has hitherto never been appreciated in this country.

25. If the above indicates the existence of a fundamental principle, very far reaching implications are involved. Phosphorus is immediately brought to the forefront of the soils' requirements, nitrogen is relegated to second place. If care is taken of the phosphorus the nitrogen will look after itself.

26. Some realisation of these trends is evident in regained prosperity brought to the derelict area of the United States of America by the Tennessee Valley Authorities through 'phosphate manuring'. The recent experiment carried out at the Imperial Agricultural Research Institute show the power for crop production which lies behind the proper use of phosphate in Indian soils. The whole living kingdom is largely dominated by the phosphorus content of the soil. Evolution is in part an expression of the earth's phosphorus utilization.

27. In the progress of civilization and in the welfare of nations the part played by phosphorus has perhaps not yet been visualized. Phosphorus is a national asset of vital importance. The health and advancement of a nation may depend on the amount which can be put into the active circulation through the soil.

28. The need for intensive study of the use of phosphate in Indian Agriculture is urgent and pressing. India must look to her supplies and seek the means of augmenting them.

Subject 5.—Methods to maximize production of rice.—Short-term policy—(1) *Increase of area.*—(a) Under kuruvai in Cauvery delta, by opening the channels earlier by 15 days, it may be possible to increase the area by 20 per cent which may be put at 40,000 acres yielding 40,000 tons of paddy.

(b) Increase the area under Basangi, which is a heavy cropper in the Godavari East and West, by opening the canal water somewhat earlier and not penalize planting earlier than June 15th.

(c) The well digging scheme has to be reorientated in certain districts which are poor and where the ryots are not able to take advantage of the system of loans, viz., Malabar, Chingleput. The feasibility of undertaking the digging of wells by the Government themselves may be examined in the light of the above experience. By the wells, it may be possible to increase the area under second crop in Malabar and also the third crop area. With 10,000 wells we may expect 20 000 tons in Malabar itself. Further, these wells ensure a more secure harvest in the second crop as also the first crop which are usually affected by insecurity of the monsoons. In Chingleput, North and South Arcot, Cuddapah, about 20,000 tons may be expected on this account by about 10,000 wells in each district.

(2) *Intensifying the cultivation*—(a) *Manuring programme.*—The available resources of the concentrate manures of the province may be better spent in those areas which give the highest returns, e.g., in Coimbator Madura, Tinnevelly, Tanjore, Godavari and Kistna deltas. It may not be very advantageous to dissipate the use of cakes in all kinds of soils It may also be necessary to ban the use of oil cakes for other crops till

some time. (b) The extending of growing of groundnuts in all places feasible, specially on the modan of the West Coast and under certain canals during second crop season of the Godavari and Kistna deltas.

(3) *Seed multiplication.*—The results of the schemes for rapid multiplication and supply of improved strains of rice as at present operated are not as successful as one would wish them to be in the backward tracts of Malabar, Chingleput, etc. In these areas, the cultivation of the seed farms in the primary and secondary stage under direct supervision and control of the department, the provision of Government godowns in more places, so that the cultivator need not go long distances for seed and encouraging certain enthusiastic people to grow the departmental seed under direct supervision and certifying them as good seed, are calculated to speed up the multiplication of improved strains. There should only be a small difference in prices between the value of the Government seed and the local price for paddy. In the progressive areas, these efforts may be more concentrated.

By five years time it may be possible to cover 75 per cent of the total area of the province with improved strains which at modest estimate would give an increase of 150 lb. per acre and amount to five lakhs of tons on seven million acres.

The disparity in controlled prices between the 'fine' and 'coarse' rices should be small so as to encourage ryot to grow fine kinds which are usually less yielding than coarse rices.

Long-term policy.—This would include the irrigation schemes, improving the tenure laws to put the tenant on a more secure position. Improving the standard of living of the actual cultivation to bestow more attention and energy on land, production of more fertilizers are beyond the scope of the present note.

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MADRAS AGRICULTURAL DEPARTMENT,
12th December 1947.
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SUBJECT 5.

CONSEQUENT ON THE DIVISION OF THE COUNTRY, TO CONSIDER MEASURES TO BE TAKEN FROM THE SHORT-RANGE AND LONG-RANGE POINT IN INDIA SO AS TO REDUCE HER DEPENDENCE ON IMPORTS TO THE MAXIMUM EXTENT POSSIBLE, AND TO SUGGEST FIVE-YEAR TARGETS OF THE INCREASE IN SUCH PRODUCTION FOR EACH UNIT OF ADMINISTRATION COMPRISING INDIA.

The aim is to maximise production of food crops. The objective of the Department has also been to improve crop yields in the different localities. This is of course the first step towards achieving the goal of maximum production in every crop, obviously keeping the cost of cultivation at the minimum or at a reasonable level. The maximum yield that can be obtained from any crop in any locality cannot be accurately judged, unless series of experiments are conducted with necessary proportions of the factors of production, subject to the working of the law of 'Diminishing Returns'. This will take a long time, before reliable data can be obtained. However, we have sufficient experience by means of previous experiments in the line and also by the performances of strains and local yields to judge within a small percentage of error, what may be the average maximum yield that could be obtained in any locality. We have also to take into consideration the nature of the soil, inherent fertility, facilities for improvements in the art of cultivation and application of heavy doses of manures, etc., before we fix up the targets for maximum production. Of course, it is not possible to achieve the result in a short time, but the effort in this direction has to be planned over a series of years so that the target fixed as maximum production, can be reached step by step. To begin with it may be a five-year plan and to this end, the following scheme may be considered as an aid in the all-out effort of the department to maximise production in food crops.

Details of the scheme.—Every taluk is in charge of one Agricultural Demonstrator. Each firka in the taluk may be considered as an unit area in this respect, though several firkas may be covered by the same kind of soil, system of cultivation and cropping. The district work registers show no doubt the work done in the taluk, at the various villages, selected as centres and other activities of the Demonstrator in the past. But the great point is whether the work in the various taluks has been going on with the ideal of target figures in their activities, particularly in the improvement of yields of crops. Owing to transfers and heavy administrative duties, demonstrators and District Officers as well, have not been in a position to assess in a comprehensive manner, the potential wealth of each taluk of the district and formulate a programme for an intensive drive to achieve the desired results, especially in crop yields ; I may call this as the 'Firka potential' and the target as 'Firka Target'. Both may be the same for several firkas as in the case of the delta tracts, dry tracts, homogeneous garden areas, etc. It will be too much to expect of the District Officers, by themselves

in the midst of their multifarious activities now, to work out with precision the potentialities and targets for the Firkas under their jurisdiction. A separate agency is therefore necessary, to take up a thorough investigation in this connexion. The aid of the District Officers will of course be sought by this agency.

The Agency.—The creation of an agency or section for agricultural rehabilitation work under the guidance of the Director of Agriculture is recommended. This will be for the whole of the Province. Our agency may be similar to the rural rehabilitation division started in the United States of America in 1934, which has achieved remarkable results by the year 1940.* There are, it seems 75,000 workers in United States of America. "Studying every aspect of the Farmers' life and putting schemes into execution". It seems the authorities have defined the duties as follows: "To build an economic democracy that will match out political democracy, our people must have facts. Few agencies have been as persistent in digging out facts as the Department of Agriculture. The Department has had to pay more and more attention to economic and social problems as well. It has been building up a notable body of knowledge in the fields." Our Department has not been collecting very much data till now on the rehabilitation side, overburdened as we are with the *Trading Schemes and other administrative activities.* The great need, therefore, is to collect comprehensive, but intensive data for each firka indicating the potentialities and target figures for maximising production and have these data kept at the Central Institution at Madras. The information thus obtained will be available for reference by the Government through the Director of the Rehabilitation Department. As a five-year plan of work, on the basis of the data it may be possible to take up intensive work in selected localities to start with and go on extending if from year to year.

The Survey.—The first essential is, therefore, to take up investigation of each firka and assess the potential (possibilities) and the target figures. Such a detailed economic investigation can be taken up by a Senior Experienced Officer of the department with the help of experienced demonstrators placed under him for this work. About a dozen demonstrators may be guided to start the survey in selected firkas in typical regions on definite lines, chalked out by the Senior Officer. Such investigation may include other aspects than maximum production targets, such as, scope for raising of new fodders, or introduction of new crops, consolidation of holding, co-operative farming, dairy farming side-lines of farming, etc.

The survey of selected areas may be expected to be completed in the first year and survey of the other areas on the same lines will be continued in the next year. When the whole survey has been completed in the comprehensive manner aimed at, consolidation of this data may be done at the central place or places fixed for the purpose.

For the general survey of the Province, it may be possible for the Demonstrators working in the various taluks themselves to take it up since it may reasonably be expected that by that time, owing to decontrol by the Government, they may be relieved of the heavy duties

*From "The Indian Rural Problem," Sir B. Nanavati and J. J. Anjaria.

they are now performing in connexion with the 'State Trading Schemes.' The Officers who took up the typical survey of selected areas will give the necessary training to the demonstrators to take up the work and guide them during the course of the general survey of all the areas in the Presidency.

Thus the economic investigation on these lines will then form part of the duties of the Agricultural Demonstrators. The Demonstrators should be able to finish the survey at the end of the second year

The comprehensive data thus obtained as a result of the economic survey will give a clear picture of the firka not only in its potentialities for maximum production of food crops, but also the scope for development of the area on varied lines for rural prosperity. From this point of view, a survey as outlined above seems to be of great importance at this juncture, before any large-scale attempt is made for the drive for 'Grow More Food' with a view to ultimate self-sufficiency.

It is recommended that this intensive survey may also be extended to cover the objectives mentioned in item 4 of the Agenda as the aim in both are the same, viz., increase in the yield of crops.

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AGRICULTURAL DEPARTMENT, MADRAS,
6th January 1948

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SUBJECT 5.

Maximising Food Production

The estimated average annual production of rice in the Madras Presidency is nearly 5 million tons. The estimated annual requirements of the Province is about 7 million tons, leaving a deficit of nearly 2 million tons. So far as the other cereals are concerned, the production is nearly 3 million tons and most of it is consumed in the centres of production. These cereals are cultivated mostly under rein-fed conditions and as such the area and production are determined by seasonal conditions and no definite targets can be aimed at for these cereals. The only cereal for which targets can be fixed is rice and the following proposals are submitted to make up the deficit of 2 million tons in the course of ten years.

Short-range policy.—The lands are at present at a low level of fertility due to indifferent cultivation and inadequate manuring.

Facilities for better methods of cultivation within the reach of the ryots should be provided, as indicated below:—

(1) Supply of improved agricultural implements at a price which will be within the reach of the ordinary ryots. Tractors and other mechanized implements should be made available at a low rate of hire for reclamation of new areas.

(2) The use of green manure seeds, oil cakes, etc., should be made more popular and their supply arranged to ryots through departmental depots. Bulky, organic manures should be conserved and utilized for manuring crops. Large-scale planting of green leaf yielding plants and trees must be encouraged in suitable waste lands. Increase in the production of oil cakes in the Province by expending the oil-mill industry and by the utilization of bones in rural areas after calcination are other measures to be undertaken.

(3) *Irrigation facilities.—The scheme of subsidized well sinking* should be extended for another period of five years. Extension of the electricity for lifting water in rural areas should be taken up.

(4) Improved and disease-resistant strains of paddy should be multiplied under seed-farm conditions and supplied to ryots.

(5) Prevention of pests and diseases on cereals will contribute for keeping up their production level.

Long-range policy.—(1) Extension of cultivation in uncultivated lands. The area of uncultivated land is estimated to be about 8 lakhs of acres. About 4 lakhs of acres can be brought under cultivation within the next five years and the rest in the course of the next five years.

(2) *Irrigation projects.*—The proposed irrigation projects in hand, when completed, are expected to bring enough lands under cultivation to produce a million tons of rice in the course of ten years.

(3) Restoration of tanks, construction of minor irrigation works, etc., will help to increase the production.

(4) There is a serious shortage of chemical manures. Production in large quantities of Ammonium Sulphate, Superphosphate, bonemeal, etc., by the establishment of power factories must be arranged as a long-range policy.

(5) Fish-curing yards should be started to increase the output of fish manure.

To ensure successful production, it would be necessary to guarantee minimum prices and assured makets for agricultural produce. Another factor which would also influence production is the legislation ensuring security of tenure to tenants, as also compensation for improvements effected. Loans at cheap rates of interest either through co-operative societies or otherwise should be arranged to ryots on an extensive scale.

The estimated targets for the short term (5 years) and the long term (10 years) have been worked out roughly in the accompanying statement.

Statement showing estimated targets for the short term (5 years) and long-term (10 years)

Targets of increased production (in tons)

Particulars	Short range				
	1948–49	1949–50	1950–51	1951–52	1952–53
(1)	(2)	(3)	(4)	(5)	(6)
1. Agricultural implements and tractors	10,000	15,000	175,000	200,000	250,000
2 Proper manuring	10,000	15,000	175,000	200,000	250,000
3 Irrigation	10,000	15,000	175,000	200,000	250,000
4 Improved seeds	10,000	15,000	175,000	200,000	250,000
5 Prevention of pests and diseases ..	50,000	75,000	80,000	100,000	125,000
Long range					
1 Extension of cultivation ..	..	..	..	..	..
2 Irrigation projects	..	..	..	..	..
3 Restoration of tanks, etc. ..	..	..	..	..	..
4 Establishment of factories and 5 Fish-curing yards	..	..	..	..	..
Total ..	90,000	135,000	780,000	900,000	1,125,000

Particulars	Long range				
	1953–54	1954–55	1955–56	1956–57	1957–58
	(7)	(8)	(8)	(10)	(11)
1 Agricultural implements and tractors	250,000	250,000	250,000	250,000	250,000
2 Proper manuring	250,000	250,000	250,000	250,000	250,000
3 Irrigation	250,000	250,000	250,000	250,000	250,000
4 Improved seeds	250,000	250,000	250,000	250,000	250,000
5 Prevention of pests and diseases ..	125,000	125,000	125,000	125,000	125,000
Long range					
1 Extension of cultivation ..	10,000	20,000	40,000	100,000	200,000
2 Irrigation projects	100,000	200,000	500,000	600,000	100,000
3 Restoration of tanks, etc. ..	10,000	20,000	40,000	60,000	100,000
4 Establishment of factories and 5 Fish-curing yards	10,000	20,000	40,000	60,000	100,000
Total ..	1,255,000	1,385,000	1,745,000	1,945,000	2,525,000

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AGRICULTURAL DEPARTMENT, MADRAS,
6th January, 1948.

A NOTE ON SUBJECT 5.

Before any plans can be discussed for increasing the production of food, particulaly cereals, in India, the first thing to be done is to consider why present production is at such a low ebb in this country. The following table taken from "The Indian Rural Problem" by Sir Manilal Nanavati, President of the Indian Society of Agricultural Economics, shows clearly how very low crop yields in India are relative to out-turns in other countries.

	Wheat	Rice	Maize	Sugarcane	Cotton	Tobacco
	(lbs. per acre)					
Egypt .. .	1,918	2,998	1,891	70,302	535	..
Germany .. .	2,017	..	2,828	..	..	2,127
Italy .. .	1,383	4,568	2,079	..	170	1,130
Japan .. .	1,713	3,444	1,392	47,534	196	1,665
U. S. A.	812	2,185	1,579	43,270	268	882
Java .. .	..	..	..	1,13,570	..	..
China .. .	989	2,433	1,284	..	204	1,288
India	660	1,240	803	34,944	89	987

Sir Maniala then discusses the various causes for this state of affairs and these are enumerated below :—

(a) Deterioration of soil.
(b) Inadequate water supply.
(c) Defective cropping systems.
(d) Lack of good seed.
(e) Poor livestock and equipment.
(f) Subdivision and fragmentation of holdings.
(g) Agricultural finance.
(h) Agricultural marketing and transport.
(i) Land tenure and tenancy system.

I would add two other causes

(i) The low level of the national income, and
(ii) Wastage of fertilizing material.

2. Having now tabulated the causes which have led to under-production in India, the next step is to consider the remedies for improvement, and the following sub-division of long-range and short-range measures is suggested :—

Long-range.—

(a) Increase of industrialisation.
(b) Increase of irrigation facilities.
(c) Improvement of agricultural finance and marketing.
(d) Reform of the land tenure system.
(e) Consolidation of holdings.

Short-range.—

(a) Encouragement in the composting of all manner of organic waste.
(b) The supply of fertilizers and cake.
(c) The supply of good seed.
(d) Provision of good implements.
(e) Improvement of village herds.
(f) Discouragement of certain forms of cropping cotton-juar for instance.
(g) The adoption of simple and soil conservation methods.

3. The long-range measures indicated are outside the immediate purview of the department of agriculture; they are matters for the Central and Provincial Governments to deal with and all are already receiving attention, except perhaps the consolidation of holdings.

4. As regards short term measures, I have purposely placed composting at the head of the list. From the statement given in para 1, it will be seen that the yields of crops in China are any thing from 51 to 100 percent higher than they are in India, although the conditions in both countries are very similar. Small as the average holding is in India, people in China are able to live on little more than half the cultivated area per head that is available in this country, and there is no doubt that this state of affairs is very largely accounted for by the meticulous attention which the Chinese give to preserving all manner of waste and returning it to the good earth. The work that the Government of India have inaugurated in this direction is most commendable, but it has to be intensified a hundred fold if it is really to bear fruit. The soil itself is being undernourished and until it is restored in condition, the use of better seeds, fertilizers and better implements are mere, palliatives. That this is no mere pessimistic utterance is borne out by the following figures which have also been abstracted from "The Indian Rural Problem."

	Rice			Wheat			Sugarcane		
	Bengal	Bihar	C.P.	Bombay	Bengal	C.P.	Bombay	Delhi	U.P.
	(lbs. per acre)								
1931-32	961	912	718	430	525	429	6,071	3,135	1,493
1940-41	652	519	419	385	451	397	5,782	2,531	1,096
Decrease	309	393	299	45	74	32	289	604	397

These figures prove conclusively that there is something basically and fundamentally wrong in Indian agriculture, and I venture to suggest that what is wrong is the neglect on the part of the cultivator to restore to the soil the waste products of agriculture and nature generally. To rectify this state of affairs, the Government of India should be asked to intensify the drive it has already started in connection with the composting of municipal and village wastes and that in the provinces and States the direction of this drive should rest with the Minister in charge of the port-folio of Public Health and/or Agriculture, and not be passed on to a departmental head.

5. I now quote an extract from F.A.O. Commodity Series No. 1 :—

"In India there has been a gradual expansion in the acreage under wheat during the past forty years, but a decline in yields per acre and, consequently, only a very slight increase in output. Apart from certain limited areas, there have been no marked improvements in farm practices or in the use of quality seed, animal manure and artificial fertilizer. In Japan, on the other hand, wheat production has been deliberately fostered and the records show a rapid increase in both acreage and yields per acre. The output, although twice as high as at the beginning of the century, has not yet reached 1.4 million metric tons (50 million bushels) and remains small compared with the production of India and the very large production in China. The Japanese practice intensive cultivation and, as with other crops, obtain yields per acre much higher than those obtained in China or India and much more comparable with those of Europe".

As a second recommendation, therefore, I would suggest that an officer be sent to Japan to study and report on the different measures, legislative, educational and technical by which these astonishing results have been achieved.

C. A. MACLEAN,
Commissioner of Agriculture.

SUBJECT NO. 5.

(Note by Mr. D. R. Sethi)

The Problem of agricultural production was discussed by the Indian Council of Agricultural Research fairly comprehensively sometime ago and the results of these deliberations were embodied in the Indian Council of Agricultural Research Memorandum on 'Agriculture and Animal Husbandry Production in India'. In that Memorandum food deficiencies have been pointed out and targets for production of various items to ensure a balanced nutritive diet of the people of this country, have been laid down.

2. How production is to be stepped up has been indicated in general terms but certain vital aspects of agricultural production have

not been dealt with. It is, therefore, suggested that the Crops and Soils Wing of the Board of Agriculture should consider the following points :

3. It is obvious that if the targets indicated in the Indian Council of Agricultural Research Memorandum are to be ever achieved crop planning must be undertaken. The difficulties that have to be faced in such crop planning should be appreciated. The conflicting claims of cash crops versus food crops have to be assessed and the planning has to be done irrespective of provincial boundaries or parochial desires.

4. Even if it is possible to prepare a crop plan for the whole of the country it will then have to be broken down right to the single village unit to individual grower's holding. The enforcement of such a plan officers administrative difficulties. Is it practicable under the present agricultural economy to carry out any crop plan on the existing uneconomic holding of the villager ? If not, how is such a plan to be worked ? It is difficult to visualize that every single cultivator in the 7 lakh villages in this country would immediately fall in line with any crop plan that may be produced. This being so, would it not be necessary for the Governments in this country, assuming that they accept the plan, to enforce such a plan by legislation. If such enforcement is to be effective, would the administrative machinery required be within the means of this country. These are vital problems with which the production of a crop plan has no meaning at all.

5. It is time the Board of Agriculture faced realities and indicated whether the targets laid down in the Indian Council of Agricultural Research Memorandum are at all practicable of achievement on the basis of the existing agricultural economy of small holdings. I maintain that the problem is beyond the realm of practical politics unless the whole land tenure system of this country undergoes a radical change. The production targets can only be achieved if the village itself can be treated as the unit of production instead of the individual cultivator in every village. This naturally implies some type of nationalization of land and joint or co-operative farming by the villagers.

6. Under the orders of the Government of India the undersigned has prepared a short-term cereals production plan to cover the next 5 years. A copy of this plan is attached. The production aimed at is 3 million annual tons in the Provinces on a permanent basis from the 5th year onwards. During the period of 5 years production is to be stepped up gradually to reach the figure indicated above. First year's experience has indicated that due to extreme shortages of supplies required for the execution of even this modest plan the goal aimed at is not likely to be achieved. The Board might discuss, taking into consideration the availability of supplies within the country, as to what is the target that can be achieved and how this could be done. I may incidentally mention that the target of 3 million tons has been broken down Province-wise and the Provinces has individually accepted their own targets.

APPENDIX I.

Technical Note on the ways and means of increasing the production in foodgrain in all the Provinces by 3.0 million annual tons within 5 years.

I have been asked to present as briefly as possible a picture of the efforts needed to produce 2.5 million tons of foodgrains annually from 1951-52. In the following pages I have attempted to do this as also a rough estimate of the costs involved. In the ultimate it means that a village is to be organised to produce an additional 4 tons annually from the 5th year onwards.

Given the full co-operation of the Provinces and assuming that goods and services for the execution of this plan are made available, the production goal can in my view be achieved through the adoption of the following measures :—

I. G.M.F. Works—

It is assumed that the Governments in India will provide, where necessary, such material and machinery as cannot be obtained easily.

A(i) By constructing 300,000 new surface percolation wells, each well to irrigate on an average 6 acres or a total of 1.8 million acres. Every 5 acres thus irrigated will produce at least 1 ton of additional foodgrain. The overall production from this measure will be 300,000 tons per annum. The average cost of one such well including a suitable water-lifting appliance is estimated at Rs. 1,200. Cultivators cannot afford this cost. They can be expected to spend upto Rs. 600 per well, no more. The other Rs. 600 will have to be given as a subsidy. Total cost for this measure will therefore be Rs. 18 crores in 5 years.

(ii) By improving 300,000 existing wells—there are about 3.4 million wells in the country and at least 25% need improving. The improvements will comprise re-excavation, deepening, borings, installing either open and or small diameter strainer tube and other such measures so as to ensure an average yield of 2500 to 3000 gallons per hour. The improved well will irrigate on an average an additional 2 acres and the total area thus commanded will amount to 600,000 acres. Every 5 acres thus irrigated will produce an additional one ton of foodgrains and the total additional yield will thus be 120,000 tons per annum. It is estimated that the cost per well be Rs. 400 on an average. Cultivator will be expected to bear half of the cost, the other half being given as a subsidy. Total cost on account of this measure would thus be Rs. 2.25 crores.

B(i) Minor private Irrigation Works.—These may be defined as all new constructions and improvements of such works in existence, other than surface percolation wells and tube-wells, undertaken either by individual cultivators or by co-operative societies or village committees, generally speaking such works will comprise tanks, bhandaras, minor inundation channels, small seasonal streams etc. Such works will be encouraged wherever practicable throughout the country and in

the 5th year are calculated to irrigate an additional 300,000 acres. Six acres commanded by such works will yield an additional ton of food. The total additional foodgrains from this measure would be 50,000 tons per annum. The cost of such works is estimated at Rs. 150 per acre of commanded area. The cultivator is expected to bear half of this cost, the other half being given to him as a subsidy. Total cost on account of this measure would thus be Rs. 2.25 crores.

(ii) Minor Public Irrigation Works.—These may be defined as all new construction and extension of and improvements to all such existing constructions as will produce additional food by the end of the year 1951-52. They shall not include surface percolation wells, tube-wells, river and stream pumping installation multipurpose projects and any other irrigation projects which are not expected to produce more food by the end of the year 1951-52. Usually such works will consist of large storage tanks, reservoirs, bhandaras, extension and improvement of canal distributaries etc. It is not an impossible task to undertake such public minor irrigation projects which in the course of 5 years will irrigate 500,000 acres of unirrigated land. It is probable that there will be 10,000 such units each capable of irrigating on an average about 50 acres. This land will yield an additional one ton of foodgrain for every 5 acres and the total additional yield from the fifth year onward will be 100,000 tons annually. The cost of this measure will vary according to the nature of each work but it is safe to estimate that on the acre basis it will be of the order of Rs. 200. Capitalised value of the net revenue return may be estimated at Rs. 50 per acre and net cost would therefore be Rs. 150 per acre or Rs. 7.5 crores for the project.

C(i) Private Land Improvement Works.—These may be defined as all works other than irrigation works undertaken by individual cultivator, co-operative societies or village committees. Ordinarily these will include reclamation of waste lands, improvement of marginal lands, drainage of culturable areas, conservation of soil and water, etc. There is a fairly large scope in this field of work if the active co-operation of the cultivator is secured through village committees panchayats or co-operative societies and it should not be difficult to bring into better production at least, 500,000 acres in the fifth year. Ten acres improved under this project will yield a ton of additional foodgrain and the yield in the fifth year will be 50,000 tons per annum. Here again the cost would vary with each type of work but on an average will be about Rs. 100 for every acre improved and this will require a subsidy of Rs. 50 per acre. The total cost would therefore be Rs. 2.5 crores.

(ii) Public Land Improvement Works.—These will include all land drainage, land reclamation and land development projects which are undertaken as Public Works and which will go into production in 1951-52 at the latest. These will include control of deeprooted weeds, reclamation of culturable wastes, contour bunding and other soil conservation measures, drainage projects etc. The field here is large and if the works are carried out with the aid of mechanical appliances, it would be practicable to handle 2 million acres during the five years

period. An additional ton of food will be forthcoming from every 10 acres so improved and the total additional yield from this measure would amount to 200,000 tons in the fifth year. The cost would vary with the type of work and may be taken to average Rs. 100 per acre. Cultivators who benefit from the scheme would be expected to share a part of the cost which should not exceed 25%. The net cost would then be Rs. 75 per acre or Rs. 15 crores.

D(i) Private River Pumping Installations.—Millions of gallons of water annually run down the river, streams and nallas to waste and yet it is not an uncommon sight to see that hundreds of thousands of acres of crops along the banks of drainage channels suffer for want of water if the rains are not in time. It is not a difficult undertaking to pump up water from these sources and supply badly needed irrigation for a better harvest. All that is needed is a suitable type of pumping outfit that can be owned and operated by an individual cultivator, by a co-operative society or by a village committee. The difficulty lies in the fact that private owners of the types stated cannot afford the whole cost of such sets. If these pumping sets are supplied on a subsidised basis thousands of them can go into operation within a short period and will produce additional food. To irrigate 500,000 acres by this means during a period of 5 years is not an impossible proposition. A suitable pumping set with a discharge capacity of 10-15 thousand gallons per hour would irrigate 100 acres. On this basis 5,000 sets will be needed during the 5 years and their use would result in at least 100,000 tons of additional food per annum. The cost of each installation is estimated at Rs. 100.000 each but half of this would be borne by the owner or owners. The net cost to the scheme would be Rs. 2.5 crores.

(ii) Public River pumping installations.—What has been said in the foregoing paragraph applies with greater force to public installations for pumping irrigation water from the same sources. In this case the pumping installations will have to be of much larger capacity —probably 3 to 5 cusecs each—which will be operated either by power supplied from public supply systems or by self-contained power sources. It is not impracticable to inaugurate schemes which in the 5th year will irrigate 1.5 million acres. An extra ton of foodgrain from every 5 acres thus irrigated would certainly be secured resulting in the 5th year in a net addition of 300,000 tons.

Assuming that a standard 5 cusec pumping unit is used, it would require some 3000 such sets on the assumption that each set would work 16 hours a day during the irrigation season. A rough estimate of the cost of a self contained unit with an oil engine may be taken to be Rs. 20,000. The total gross expenditure involved will be approximately Rs. 6 crores. On the assumption that the net revenue return will be offset by the working expenses the net cost may be estimated at Rs. 6 crores. This scheme would be particularly useful in the east U.P. South Bihar and Chota Nagpur, North and West Bengal, Orissa, parts of the C. P., Bombay and parts of the N.W.F.P.

The Grow More Food Works enumerated above are therefore capable of achieving the following results at the total cost stated against each.

	Acreage	Yield of additional food	Cost
	Millions	Tons	Crores Rs.
1. Surface Percolation Wells	2·4	480,000	24
2. Minor Irrigation works both public and private ..	0·8	160,000	9·75
3. Land Improvement Works both public and private	2·5	250,000	17·5
4. Private and Public River Pumping installations ..	2·0	400,000	8·50
Total ..	7·7	1,290,000	59·75 say Rs. 60 crores.

II Grow More Food Supplies.—

A. Manures and fertilisers.—To step up food prooduction appreciably in the country there must be enough water to irrigate the crops and there must be sufficient quantities of manure to adequately fertilise the irrigated crops on which alone the greatest response to manuring can be secured. The question of water supplies has to a small extent been dealt with under the Grow More Food Works. In this Section the question of supplying adequate quantities of manures and fertilisers and distribution of improved seeds is provided for.

For the purpose of Grow More Food intensification work, we need to confine ourselves to only the two major cereal crops, namely, rice and wheat. A normal rice crop removes annually from the soils on which it grows 30 lbs. of nitrogen and 20 lbs. of phosphoric acid per acre while irrigated wheat similarly removes 35 to 60 lbs. of nitrogen and about 30 lbs. of phosphoric acid. It is now a well-known and established fact that the fertility of Indian soils has been established for centuries past at the lowest level of production and unless we are in a position to replace at least that plant food which is removed by the crops annually, we cannot hope to get any increased yield whatsoever It is on this basis that the following plan has been proposed. Experimental data has established that if in the case of rice 30 lbs. of nitrogen and 20 lbs. of phosphoric acid are applied, an increased yield of 4 maunds of paddy can be obtained, while in the case of wheat if 30 lbs. of nitrogen is applied, an extra yield of 2 maunds per acre does result (in the soils in wheat areas there is no deficiency of P_2O_5 which exists in rice soils).

A(i) Rice.—There are 20.7 million acres under irrigated rice in British India. It is proposed that a programme should be inaugurated which will gradually lead upto the manuring of 1/4 of this area

amounting to 5 million acres in the fifth year. Manured on the basis stated above, this acreage will give an increased yield amounting to 800,000 tons of paddy or 500,000 tons of rice in the 5th year. For purposes of supplying the 30 lbs. of nitrogen and 20 lbs. of phosphoric acid per acre, the following mixture is considered suitable.

(*i*) 125 lbs. of ammonium sulphate	..	25 lbs. of nitrogen.
(*ii*) 100 lbs. of oilcake	..	5 lbs. of nitrogen.
(*iii*)* 50 lbs. single super and Bonemeal	..	10 lbs. P_2O_5.

The total quantities for 5 million acres of these fertilizers and manures in the 5th year will, therefore, be

	tons
(*i*) Ammonium sulphate	2[illegible]0,000
(*ii*) Oilcakes	223,000
(*iii*) Single superphosphate and Bonemeal	110,000

It is of course impossible to bring under this programme of manuring *the full acreage in the very first year of the five years programme.* Endeavour has been made to increase the acreage gradually from 2.5 million acres in the first year to 5 million acres in the 5th year. The table below gives the manuring programme, the acreage to be covered, the estimated additional yield, the cost of the manures in each year and the subsidy that will have to be paid to get these manures to go into action. From this table it will be seen that the aggregate total net cost to the State during the 5 years will amount to Rs. 18,94,70,000 and in return for this expenditure the country will secure a total additional yield over 5 years amounting to 2,185,000 tons. In the 5th year the additional yield from 5 million acres will be 500,000 tons.

Manurial Programme—Rice.

Year	Manures and fertilisers	Quantity	Acreage and yield of Rice	Cost of Manures	Subsidy @ 33⅓% of cost
		Tons		Rs.	Rs.
1947-48	Am. Sulphate..	140,000	2·5 million acres and 2,50,000 tons additional rice.	4,20,00,000	
	Oil Cakes	112,000		1,12,00,000	
	Super and Bone-meal.	50,000		1,00,00,000	
			Total ..	6,32,00,000	2,11,00,000
1948-49	Am. Sulphate..	187,000	3·33 million acres and 324,000 tons additional rice.	5,61,00,000	
	Oil Cakes ..	149,000		1,40,00,000	
	Super and Bone-meal.	67,000		1,34,80,000	
			Total ..	8,44,80,000	2,81,60,000

*It is probable that only half the area will need P_2O_5.

Year	Manures and fertilisers	Quantity	Acreage and yield of Rice	Cost of Manures	Subsidy @ 33⅓ % of cost
1949 50	Am. Sulphate..	240,000	1,445 million acres and 432,000 tons additional rice.	7,47,00,000	
	Oil Cakes ..	100,000		1,99,00,000	
	Super and Bone meal.	80,000		1,78,00,000	
			Total ..	11,24,00,000	3,74,70,000
1950-51	Am. Sulphate..	2,80,000	5·0 million acres and 5,00,000 tons additional rice.	8,40,00,000	
	Oil Cakes ..	2,23,000		2,23,00,000	
	Super and Bone-meal.	1,10,000		2,20,00,000	
			Total ..	12,83,00,000	4,27,70,000
1951-52	Am. Sulphate..	2,80,000	5 million acres and 500,000 tons additional rice.	8,40,00,000	
	Oil Cakes ..	2,23,000		2,23,00,000	
	Super and Bone-meal.	1,10,000		2,20,00,000	
			Total ..	12,83,00,000	4,27,70,000
	Total additional rice.	..	2,006,000 tons.		
	Total for 5 years	..	..	51,07,00,000	17,22,70,000
	Add 10% storage and detail distribution.	..	..	5,16,00,000	1,72,00,000
			GRAND TOTAL ..	56,33,00,000	18,94,70,000

A. (ii) Total irrigated area under wheat in British India is 12 million acres. During the first five years it is proposed to manure 1/4 of this area amounting to three million acres. On the basis of 30 lbs. of nitrogen per acre giving an additional yield of 2 maunds per acre this area will give an additional yield of 230,000 tons foodgrains.

The 30 lbs. of nitrogen to be applied per acre on 3 million acres will be made up of the following mixture in order to apply a balanced manure enabling the maximum use being made of the chemical fertilizer.

(*i*) Ammonium sulphate 125 lbs. per acre	25 lbs. nitrogen.
(*ii*) Oilcakes 100 lbs. per acre	5 lbs. nitrogen.
Total ..	30 lbs. nitrogen per acre.

In this case it will not be possible to bring in the whole of the 3 million acres under the manures in the first year. The programme envisages a start with 880,000 acres in the first year gradually rising upto 3 million acres in the 5th year. The table on next page gives in detail the quantities of manures and fertilizers required during each of the

five years beginning from 1947-48, the acreage proposed to be covered in each of the years and the estimated additional yield that is expected to accrue as also the total cost of these operations. From this table it will be seen that the overall production during the 5 years is estimated at 774,000 tons at a net cost to the State of Rs. 7,93,94,000.

Manurial Programme—Wheat.

Year	Manures and fertilizers.	Quantity	Acreage and yield	Cost	Subsidy @ 33⅓ % of cost
		Tons		Rs.	Rs.
1947-48	Am. Sulphate..	49,600	886,000 Acres.	1,48,80,000	
	Oil Cake ..	39,684	65,200 Tons.	39,68,400	
			Total ..	1,88,48,400	62,82,800
1948-49	Am Sulphate	74,400	1,333,000 Acres	2,23,20,000	
	Oil Cake	59,500	98,900 Tons.	59,50,000	
			Total ..	2,82,70,000	94,23,400
1949-50	Am. Sulphate	111,600	2,000,000 Acres.	3,34,80,000	
	Oil Cake	89,300	150,000 Tons.	89,30,000	
			Total ..	4,24,10,000	1,41,40,000
1950-51	Am. Sulphate	167,000	3,00,000 Acres.	5,01,00,000	
	Oil Cake	134,000	230,000 Tons	1,34,00,000	
			Total ..	6,35,00,000	2,11,70,000
1951-52	Am. Sulphate	167,000	3,00,000 Acres.	5,01,00,000	
	Oil Cake ..	134,000	230,000 Tons.	1,34,00,000	
			Total ..	6,35,00,000	2,11,70,000
	Total additional grain.		774,100 Tons.		
	Total Cost ..			21,65,28,000	7,21,76,000
	Add 10% on storage and distribution.			2,16,52,800	72,17,600
			Total ..	23,81,80,800	7,93,93,600

On the basis of the cultivator's price for wheat and rice being Rs. 200 per ton of these grains, the application of manures on the present price of manures and fertilizers is a wholly uneconomic proposition. Normally no cultivator would apply these; and this is the reason why manures have not been used in the past, unless he gets at

least 33% return on the expenditure he incurs in manuring his crops. In order that the manures go into action and the additional 2,790,000 tons of foodgrains are secured, it is vital that the cultivator be given a subsidy at the rate of at least 33% of the gross cost of manure to him. On this basis the subsidy would amount to Rs. 26,88,64,000. And this basis of subsidy will have to be continued to be given year after year until the price relation between the cost of manure and the cultivator's price for the grain is of the order of Rs. 150:200 (cost of manures Rs. 150 per ton=cultivator's foodgrains price Rs. 200).

The sources of supplies of manures proposed in this scheme need to be explained.

We will require 447,000 tons of sulphate of ammonia per annum from the 4th year onwards. The Government Sulphate Ammonia factory which is expected to come into production in 1949 will produce 350,000 tons of manures per annum. The Travancore Factory which is coming into operation this year is expected to produce 50,000 tons of this fertilizer annually. The existing indigenous production from the iron and steel works and from coal fields is some 20,000 tons a year. From 1949, therefore, we will have 420,000 tons of sulphate of ammonia per annum leaving some 27,000 tons to be imported. During 1947-48 it is proposed to ask for an import quota of 300,000 tons which will be raised to 350,000 tons in 1948-49 in order to ensure adequate supplies under this programme.

During 1947-48 we propose to ask for an allocation of 300,000 tons of sulphate of ammonia. If we get the whole of it we would have 370,000 tons supplies available in the country which would enable us to meet the requirements of the two major cereals and still leave substantial quantities in hand for other food crops, particularly, sugarcane, potatoes and vegetables.

The estimated production of oilcakes in the country is 1,800,000 tons. Of this quantity 1 million tons are required as cattle feed and 800,000 tons are available for manuring of crops. In the 5th year of this programme 357,000 tons are required for the manuring of these two cereals and we would thus still have 443,000 tons of oilcakes available for other food crops and especially for sugarcane, potatoes and vegetables.

With regard to superphosphate and bonemeal, the position is as follows :—

We are producing some 30,000 tons of bonemeal and 10,000 tons of single superphosphate at present. Our needs, however, according to this programme are 50,000 tons in the first year rising gradually to 110,000 tons in the 5th year. In the past this country has exported all its bones abroad and in return has been getting superphosphate at very high cost. Our raw material sources for the manufacture of supherphosphate are believed to be more than ample to meet our requirements with regard to the manuring programme which is now being proposed. It is, therefore, of the utmost importance that this country should encourage the production of superphosphate from bones

as quickly as possible and our target, in my view, should be the production of at least 70-80 thousand tons of this manure in the year 1949-50.

B. Improved seeds—One of the major activities of the Departments of Agriculture in provinces during the past 35 years has been the production and distributions of improved types of seeds of the major food crops. It is an established fact that improved foodgrain seeds can give an increased yield of 10 per cent, all other things being equal.

The multiplication and distribution of improved seed has to go through a chain of operations before sufficient seeds become available to cover any appreciable area. Crop botanists research results in a small amount of new type of seed of a given crop. This seed is tested for performance and when it has established its superiority it needs to be multiplied through four stages before sufficient quantities are available for distribution on a large scale to growers. The first stage is the multiplication from mother seed to produce nucleus seed: This is done on a Government experimental farm. The second stage is the multiplication of the nucleus seed for production of basic pedigree seed on a Government seed farm. The third stage is the multiplication of the basic pedigree seed through selected growers, for convenience purposes called "A" growers. These are usually comparatively larger growers who have the facilities for multiplying pedigree seeds on compact blocks of lands and who are in a position to supply the labour required for roguing and looking after the seed crop. The fourth and last stage in the multiplication is the multiplication of the seed grown by "A" growers through a larger number of private "B" growers merely for the purpose of getting larger quantities multiplied. Here again, it is necessary to have the crop again in as compact areas as possible for purposes of roguing to ensure the purity of the seed.

The seed produced by the "B" growers is then ready for distribution to the ordinary cultivator who by the use of this seed can get 10 per cent. more yield from his crop.

A great deal of such multiplication and distribution of improved seed has already occurred in the case of wheat in the Punjab the largest grower of this crop. It is, therefore, proposed not to include wheat seed multiplication and distribution in this scheme.

Although a great deal of work has been done on rice and improved types exist in every rice growing province, much headway with the multiplication and distribution of these types on a large scale has not been achieved so far for various reasons chief amongst which is that the chain of multiplication required has not been organized on a large enough scale. An intensive effort is required to be made now to multiply and distribute the existing improved types of rice seed in order to get a substantial additional productions for this badly wanted foodgrain.

There are some 20 million acres under irrigated rice in British India. The aim is to cover at least 5 million acres out of this area with improved types in the year 1951-52 to secure an additional yield

of 290,000 tons. The chain of multiplication for the seed will require of this area which will amount to approximately 25 lakh maunds of "B" growers seed be as follows:—

(i) In 1947-48, 30 acres will be required to produce 450 maunds of nucleus seed from mother seed.

(ii) In 1948-49, the nucleus seed will cover 830 acres on Government seed multiplication farms spread throughout the rice growing areas in Bihar, Bengal, Orissa, C. P. and Madras and will produce 12,450 maunds of pedigree seed;

(iii) In 1949-50, the pedigree seed will cover 24,000 acres through the "A" growers. This acreage will produce 298,800 maunds of "A" seed. The "A", grower usually does not part with more than 50% of his harvest and the collection from him would, therefore, be not more than 173,000 maunds—a quantity which will be needed to cover 346,000 acres of the "B" growers in 1950-51.

There will thus be 346,000 acres under "B" growers. This acreage will produce 41,52,000 maunds of "B" seed from which 25 lac maunds will be taken for covering 5 million acres of the cultivator's cropped area. In the case of the nucleus seed and seed produced on the Government seed multiplication farms full cost will have to be borne by the Government. In the case of 'A' and 'B' growers, a sufficient attractive premium will have to be paid in order to ensure the proper roguing of the crop, to maintain its purity and in order also to offer a sufficient incentive to both 'A' and 'B' growers to multiply the seed on behalf of the distributing Agency. Experience has shown that a premium of even rupees two a maund under the conditions prevailing during the past few years has not been attractive to get the seed multiplied. In order to ensure the co-operation of both the 'A' growers and 'B' growers, it is proposed to give them rupees four and rupees three per maund respectively as premiums, which it is believed would be attractive enough to ensure the proper multiplication of the seed. The total net cost during the four years mainly for the multiplication of the seeds amounting to 25 lac maunds would be Rs. 85,00,000. Storage and distribution costs, experience has shown come to nearly 20 per cent. of the total gross cost of the seed. The gross cost of the seed has been estimated on the basis of Rs. 10 per maund of paddy to be Rs 2,80,00,000. The storage and distribution costs would, therefore, be 56 lacs, making the total net cost of the seed to be incurred by Government to amount Rs. 1,41,00,000. This is the amount which will have to be spent to get 288,000 tons of additional paddy.

(C) The additional production from supplies.—Use of fertilizers and manures on rice and wheat and use of improved seeds on rice only will produce 730,000 tons of additional foodgrains. The total acreage involved will be 13 million acres in the 5th year.

(D) Capital investment and services.—The plan reveals that an expenditure of the order of 88.30 crores is necessary. Provincial Governments will have to incure some capital expenditure on some equipment and buildings required for the storage and distribution

of manures, fertilizers and seeds. They will also have to incur expenditure on services to operate the Scheme. For these two purposes, the following estimate is presented :—

1. Expenditure on Public Works Scheme including manures and seeds ..	Rs. 54.80 crores.
2. Capital expenditure at 5% on (1) ..	Rs. 2.70 crores.
3. Provincial expenditure on services at 10% on the Scheme as a whole (Rs. 88.3 crores)	Rs. 8.83 crores.
Total expenditure or say Rs. 100,000 crores ..	Rs. 99.83 crores.

The present basis of financial assistance from the Centre to the Provinces for the Grow More Food campaign is on the basis of 50|50 to all Provinces except in the case of centrally administered area to whom full grant is given and on the basis of 66.2|3% to N.W.F.P., Assam and Orissa. For the next five years, it is suggested that the same basis may be continued. In the case of fertilizers and mechanized irrigation, the 50% subsidy to the Provinces be increased to 66.2|3 per cent. as these two measures will contribute the largest quantity of food.

The Centre will have to maintain its food production centre in the Department of Agriculture. In order to co-ordinate the work in the Provinces and to render advice where such is necessary, the expenditure on this account will be an additional item.

(E) In the opening paragraph of this Scheme it was stated that the ultimate aim is to produce an additional 4 ton annually in every village in British India. To do this large scale organization, intensive work and large expenditure are essential. What is still more essential is that those who have to carry out this plan must secure the co-operation and the good-will of the villager. They must get down to the village through a village committee or through a village co-operative society, survey and ascertain which of these proposals can be put through within the period and on what scale. As it is the cultivator who ultimately has to do the job, he must be freed from the usual annoying red-tapism to which under the present scheme of things, he is to submit where money is involved. Experience in the past has been that when he sets out to get a small subsidy for a particular piece of work the process through which he can secure it is not only so complicated but so harassing that he usually does not bother to take up the work.

The various measures for growing more foodgrain enumerated in the foregoing pages will produce 2.3 million tons of foodgrains. The balance 500,000 tons are left for public and private Tube-well schemes for which a separate statement, I understand, is being prepared.

For the next five years it will be necessary to keep the .94 million acres diverted from cotton and jute during 1942-43 to 1946-47 under food crops in order that the production from those areas is not lost.

Sd|- D. R. Sethi.

SUBJECT NO. 5.

SOME SUGGESTIONS FOR MEASURES TO BE TAKEN, FROM THE SHORT-RANGE AND LONG-RANGE POINT OF VIEW TO MAXIMISE THE PRODUCTION OF FOOD PARTICULARLY OF CEREALS.

BY

M. L. Mehta,

Director, Rural, Soil Surveys and Land Development.

East Punjab, Karnal.

There are two problems with the Government of East Punjab and the Government of the Dominion of India. These problems are :—

1. Finding more land for the settlement of agricultural population who have migrated from West Punjab. Making allowance for all cultivated land in East Punjab and absorption of refugee population in States, land is required for the settlement of 50,000 to 60,000 families.

2. The food position of the whole of the Dominion of India is the cause of continuous anxiety to Government and conditions are becoming worse and worse. An extract from the latest budget speech of the Finance Minister is given below. It atonce reveals the seriousness of the situation :—

> " The value of foodgrains imported into India was Rs. 14 crores in 1944-45, Rs. 24 Crores in 1945-46, Rs. 89 Crores in 1946-47 and Rs. 110 Crores in 1947-48 and Rs. 61 Crores for the half year January-June 1948. The most important lesson to be drawn from a study of our external financial position is that so long as food imports continue on the present scale, we would be confronted with the problem of an adverse balance of payments and the disequilibrium in our economy will persist. The only way to redress the balance is to increase the internal production of food ".

Regarding No. 1 *i.e.*, finding more land for refugees, in Ambala Division alone, there is an area of 6.5 lakhs of acres of uncultivated land vacated by Muslims. Of this over two lakhs exist in one district Karnal. The total area of uncultivated waste land in this district including that owned by non-muslims is approximately 6 lakh acres. In statement attached are given full particulars of the total land in Karnal district. It will be seen that in some assessment circles as much as 47 and even 52 per cent. of total land is culturable waste lying vacant. If, for purposes of development and increased food production barani areas are also combined the percentage shoots upto 90 per cent.

If the whole of the uncultivated waste land in Karnal district is brought under irrigation and colonised it will afford an opportunity to settle at least 50,000 agriculturist families. The Question now arises how to bring this area under cultivation. At present it is without any means of irrigation and carries Dhak of only stunted growth. Two schemes have been suggested one long range and the other short range. For the long range scheme three alternatives are possible :—

(a) Providing canal irrigation.

(b) Providing open wells worked by bullocks.

(c) Providing tube-wells worked by power.

(a) Canal irrigation is out of question. Even when Nangal and Bhakhra projects are completed only a very small portion of the uncultivated waste of Karnal district is proposed to be irrigated. The entire capacity of the Western Yamuna Canal is fully taxed and no water is spare for any extension.

(b) Well irrigation is dependent on a large supply of cement, coal and steel—materials which are already in short supply and amongst competing demand from different areas and multi-purpose projects in other parts of the country, prospects for giving it a very extensive trial are very remote. Besides the costs of open well irrigation are high. Time is an important factor in the present crisis and the advisability of proceeding with a tube-well scheme is justified.

(c) As mentioned above tube-wells are the answer to the question of providing more land for allotment to refugees and the increased food production that is required at the moment.

Land being available the other questions to answer are :—

(i) Whether sub-soil water in Karnal is suitable for irrigation ?

(ii) Whether the required quantity is available ?

(iii) Can equipment be found ?

(iv) What are the working costs?

An extensive sub-soil water survey of Karnal district was undertaken by the Land Reclamation Department and the Irrigation Research Institute of the Joint Punjab. The results of their survey indicated that :

(a) Water available in the sub-soil is of suitable quality for irrigation and

(b) the required quantity of water for the area proposed to be irrigated can be pumped with reasonable hope of stability of the water level.

Regarding equipment Sir Datar Singh, Vice Chairman of the Imperial Council of Agricultural Research, Shri Bajawat, Tube-well Irrigation Adviser to the Government of India and Shri Aftab Rai, Director General, Disposals have been consulted. They state that there will be little difficulty in procuring the equipment for making bores;

installing tube-wells and working them with diesel engines at least for the first set of bores which can be started almost immediately. In the meantime more engines and pumps can either be ordered or manufactured in India.

Working Costs.

It is not proposed to give in this note detailed estimates for making bores, installing tubes and strainers and the machinery required to pump water. At a very liberal estimate including working costs, cost of repairs, interest and depreciation an acre irrigation ($2\frac{1}{2}$ to 3 inch depth) would cost not more than Rs. 3|-. This will be recovered as water rate. This means the tube-well project will not be a loosing concern to Government.

Food Production.

If our immediate objective be to provide irrigation for say two lakhs of acres of culturable waste and the installation of tube-wells be spaced over a period of three years then a suitable arrangement would be to have 25 tube-wells in the first year, 75 in the second year and 100 in the third year. On a rough calculation the production as a result of irrigation from 25 tube-wells should be of the following order:—

1. Wheat on one tube-well	..	..	6,000 maunds
Wheat on 25 tube-wells	..	..	1,50,000 maunds
2. Gur on one tube-well	..	..	4,000 maunds
Gur on 25 tube-wells	..	..	1,00,000 maunds
3. Fodder on one tube-well	..	..	59,000 maunds
Fodder on 25 tube-wells	..	..	14,75,000 maunds

When the whole scheme of 200 tube-wells is in operation, the yearly production will be

Wheat : 12,00,000 maunds

Gur : 8,00,000 maunds

Fodder : 1,18,00,000 maunds

Government is at present paying Rs. 20|- per maund for imported wheat and this is being distributed on a subsidised rate of Rs. 11|- per maund. In other words Government is suffering a loss of Rs. 9|- per maund. 1,50,000 maunds of wheat produced in the first year, when the first instalment of 25 tube-wells is working, would be instrumental in a saving of Rs. 13,50,000|- to Government. On this score alone the first year scheme justifies itself.

Short Range Programme.

In Karnal district the average annual rainfall is 28.65 inches. If an attempt is made to establish a zone of field moisture capacity by concentrating the total rainfall of a given area upon a smaller area and below its surface a reserve of water can be accumulated in the soil on which normal yields of crops will be possible. This can be achieved by trenching as illustrated in figure attached. The soil dug from the trenches will be placed between them so as to form ridges.

By this means a great portion of the rain falling on the ridges will also flow into the trenches. In this manner it is considered that the average annual rainfall in the trenches would amount to over 40 inches. This is sufficient to mature a Kharif crop and also enable a rabi crop to be sown.

The distance between the trenches and their depths will vary with the type of soil, the characteristic variations in rainfall and the type of crop to be grown. Experiments are being initiated to determine the best lay out for Karnal district.

In parts of Karnal district the water-table is situated at a depth of 10 to 12 feet from the natural surface. In years when rainfall is deficient Zemindars dig kacha wells and line it with Sarkanda reeds. These kacha wells last the whole of the winter season and are capable of giving water supply sufficient to sow and mature ten acres of wheat on each well. Each such kacha well costs approximately Rs. 100.

It is estimated that on each kacha well the total produce of wheat will be not less than 150 maunds. This means one maund of wheat thus produced will cost a little over annas ten in the capital cost of the well. If it is presumed that the price of wheat remains the same as control price this year, the whole amount spent on the construction of a kacha well can easily be paid back by the Zamindar from the sale proceeds of wheat crop.

Suggestion has been made to the Revenue Department to advance taccavi loans to agriculturist families who are settled on culturable waste land in portions of the district where kacha wells are a possibility.

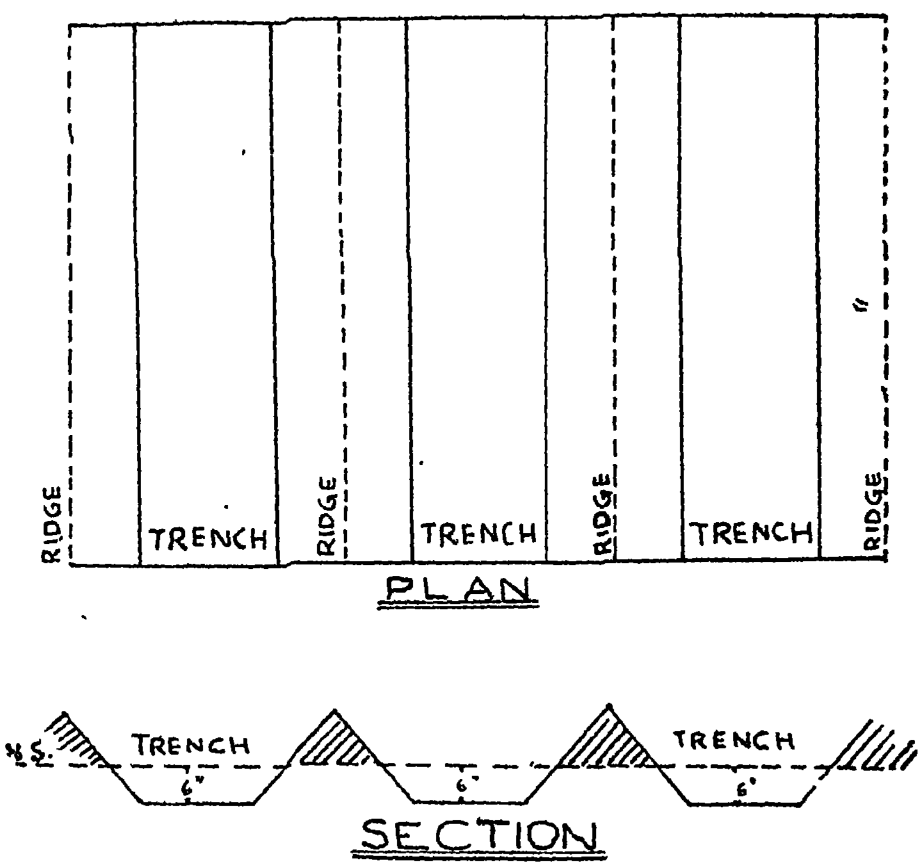
Particulars of Land available in Karnal District.

Name & Tehsil and Assessment Circle	Total area	Area not cultivated Acres		Other waste land				Area cultivated				Barani	
		Forest	Ghair mumkin (uncul-turable)	Govt waste	Area	Percentage of Total minus Ghair mumkin	Total area	Canal	Wells	Abi	Sailab	Area	Percentage of total minus ghair mumkin
Karnal Tehsil (*i*) Khadar Karnal.	61,966	..	7,321	..	17,070	31·4	37,372	1,799	20,113	1	3,755	11,701	21·5
(*ii*) Bangar Karnal.	66,119	..	13,262	..	14,696	27·8	38,206	13,701	7,634	21	..	16,850	31·9
(*iii*) Nardak Karnal.	1,49,713	..	21,127	..	18,769	37·9	79,817	33,000	8,089	54	..	38,674	30·0
(*iv*) Khadar Indri.	1,16,416	..	15,414	..	38,676	38·3	62,316	..	17,011	212	18,022	27,070	26·8
(*v*) Bangar Indri.	72,824	..	11,193	..	16,515	26·8	22,331	2,583	16,551	125	511	2,531	4·1
(*vi*) Nardak Indri.	84,878	..	11,705	..	35,298	50·3	34,854	10,663	4,929	59	..	19,203	27·4
Total for the tehsil.	5,51,916	..	83,225	..	171,004	36·5	274,926	61,746	74,327	503	22,318	116,032	29·6
Panipat Tehsil (*i*) Khadar	97,624	..	12,542	..	21,804	25·6	63,478	..	44,981	1	5,698	12,798	15·0
(*ii*) Chak Panipat.	9,937	..	1,745	..	485	5·9	7,707	750	5,962	..	..	995	12·1
(*iii*) Bangar	1,87,459	..	42,110	..	37,203	25·6	108,146	16,355	10,530	18	..	51,243	35·3
Total for the tehsil.	2,95,020	..	56,397	..	59,492	24·9	179,331	17,105	61,473	19	5,698	65,036	27·3

Particulars of Land available in Karnal District—contd.

Name and Tehsil and Assessment Circle	Total area	Area not cultivated Acres		Other waste land				Area cultivated				Barani	
		Forest	Ghair mumkin (unculturable)	Govt. waste	Area	Percentage of Total minus Ghair mumkin	Total area	Canal	Wells	Abi	Sailab	Area	Percentage of total minus ghair mumkin
Kaithal Tehsil													
(*i*) Nardak Kaithal.	2,49,344	..	14,405	178	67,686	28·8	167,075	77,940	572	152	..	88,411	37·6
(*ii*) Bangar Kaithal.	2,26,603	..	14,808	..	29,436	13·0	182,369	80,083	1,621	2	..	100,663	47·5
(*iii*) Bangar Pehowa.	44,566	..	3,204	..	20,936	50·6	20,416	3,308	3,120	6	262	13,051	33·0
Total for the tehsil.	5,20,513	—	32,417	178	118,058	24·2	369,860	161,391	5,322	160	262	202,725	41·5
Gukla Sub-Tehsil													
(*i*) Naili	2,22,810	..	41,393	2,960	116,829	64·4	61,637	13,727	7,032	194	16,270	24,414	13·5
(*ii*) Powach	37,465	..	3,740	..	11,089	32·9	22,636	2,751	8,242	94	50	11,499	34·1
(*iii*) Andarwar.	33,775	..	9,526	..	11,491	47·4	12,758	..	4,264	3	168	8,323	34·3
Total for the *Sub*-Tehsil.	2,94,050	..	54,659	2,960	139,409	58·2	97,031	16,478	19,538	291	16,488	44,236	18·5
Thanesar Tehsil													
(*i*) Khadar	29,384	..	5,724	..	4,917	20·9	18,713	..	2,112	329	4,027	11,345	47·9
(*ii*) Bangar	38,606	..	4,265	21	3,717	10·8	27,090	..	6,226	118	1,358	19,388	56·3
(*iii*) Northern Chhachhra.	92,770	1,013	6,702	..	31,736	36·9	53,355	..	9,717	875	1,767	40,996	47·7
(*vi*) Bet Markanda.	1,04,721	..	9,285	15	11,318	11·9	84,103	..	3,104	16	48,084	32,299	33·1
(*v*) Southern Chhachhra.	91,393	..	12,550	452	41,854	53·1	36,534	..	6,743	139	437	20,215	37·1
Total for the tehsil.	3,56,904	1,013	38,526	491	93,572	29·3	219,795	..	27,902	1,477	57,173	133,243	41·7
Grand total for the district.	20,18,472	1,013	2,65,224	3,629	581,535	33·2	11,40,943	2,80,720	1,88,562	2,450	101,939	561,272	32·0

SHOWING THE ARRANGEMENT OF TRENCHES & RIDGES TO ACCUMULATE RAINFALL IN TRENCHES.



SUBJECT NO. 5.

(By Mr. M. C. Bijawat).

An adequate and timely supply of good water for irrigation of crops is *Sine qua non* of any drive for intensive production of food-grains. Manure, good seed and better and scientific methods of cultivation all play their part in increasing the yield from cultivated areas. Where irrigation facilities already exist, they will produce immediate results. But where new areas have to be brought under the plough or where irrigation facilities are inadequate they cannot show full results. Water is needed at all stages of plant life germination, growth and maturing and if irrigation supply falls short at any stage the yield of crop will suffer, other scientific methods of agriculture not withstanding.

2. Of the total land area of about 800 million acres in the Indian Union about 260 million acres are actually cultivated and hardly 45 millions are irrigated from all sources. So far only about 7 per cent of the total annual runoff of the Indian rivers has been utilised for irrigation purposes. In addition there are vast quantities of water, as yet unestimated, which are flowing down to the ocean under the sub-soil of which only a very small quantity is being utilised at present for irrigation by means of open percolation wells and tube-wells. Although for various reasons topographical, climatic, rainfall etc. it is neither possible to bring the entire land area under cultivation nor of utilising completely the available sources of water for irrigating all the cultivated area, the above figures give an indication of the vastness of the scope and possibilities of extending irrigation facilities and of thereby increasing the production of foodgrains and other crops in India.

3. The various provincial Governments are fully alive to this aspect of the agricultural problem and investigation for large multipurpose water projects, of which irrigation is to be one of the main objectives, are in hand in almost every province and in some cases, preliminary projects have also been prepared. They have also got numerous irrigation projects on their 5 years G.M.F. and development programmes. When fully developed these projects are estimated to bring some 25 million acres under irrigation. The multipurpose projects which account of major part of this area will take at least 25 to 30 years to develop. Even the smallest of these projects may be in working stage in less than 10 years. And in case all the large projects in all the provinces are started simultaneously their completion may be considerably delayed owing to shortage of cement, of steel shortage of earth moving and other constructional machinery. They will not therefore help in the problem of immediate stepping up of the production of foodgrains.

4. The only hope of increasing irrigation facilities during this critical period lies in the quick formulation and execution of small irrigation projects tapping the small surface streams and of intensive exploitation of ground water by means of tube-wells. In provinces

like Bengal, Orissa and part of Bihar proper drainage of low lying areas by opening out old silted water courses and by constructing new ones offers great scope of bringing large areas under cultivation by reclaiming water logged land and of saving existing cultivated areas from flooding and damage to crops.

5. The available technical man power in the province is, however, more than fully employed in routine duties and in the preparation of large multipurpose projects. They are therefore unable to give the time and attention which the smaller projects require with the result that they are not making as much and as quick progress as is necessary under the existing circumstances. It appears necessary to earmark a definite staff in each province for the surveys and preparation of these small short term C. N. F. projects. Certain targets of extra food production have been accepted by the provincial Governments under the various irrigation heads such as :—

(a) Open percolation wells.

(b) Minor irrigation works such as small tanks and reservoirs, bund projects, flood irrigation.

(c) Drainage projects for reclaiming water logged areas or relieving flooding of crops.

(d) Lift irrigation schemes such as pumping projects from rivers, tanks and drains.

(e) Exploiting ground water resources wherever available.

Some work has been done under all these heads in various provinces but to enable satisfactory progress to be made under (b), (c) and (d) the suggestion made above of allotting a definite staff with a clear directive to the technical officers to produce schemes, at least upto the extent of targets already accepted, within a definite period seems to be essential even though this may involve a delay of a year or so in the large multipurpose. long-term projects.

6. As regards (a) the provinces are doing what is possible with the limited quantity of coal, bricks, cement steel and small pumping units.

7. For exploiting ground water, supply of cheap electric power is essential. This is at present in short supply in the Punjab, U.P. and Bihar where scope for immediate exploitation exist.

8. Appendix II with this note gives the details of the progress so far made, the proposed schemes in the various provinces and the difficulties in the way of their quick execution and explain the steps which appear to be necessary for expediting the execution of tube-well programmes.

Sd/- M. C. BIJWAT,
Irrigation Adviser.
27-3-48.

APPENDIX I.

Irrigation Statistics of India (All figures in million acres).

Name of province or state	Area: Total	Area: Cultivated annually	Area irrigated annually by all sources
India			
Provinces	452	205	40
States	356	55	6
Total ..	808	260	46
Patiala	4	3	1·2
East Punjab	20	10	6
United Provinces	68	45	12
Madras	80	40	10
Bihar	44	24	5
Orissa	21	7	1·5
Mysore	19	7	1·1
West Bengal	49	30	1·8
C. P. and Berar	63	27	1·6
Bombay	49	30	1·2
Hyderabad	53	29	1·3
Minor administration	15	0·8	0.5
Other States	280	14	2
Assam	43	7	0·2

APPENDIX II.

(Ministry of Agriculture.)

Irrigation

The only province in which the ground Water potential has been proved and where immediate results in extra food grain production can be realised by pumping up subsoil water for irrigation of crops on new areas or on areas with inadequate facilities of irrigation are the East Punjab, the United Provinces and Bihar. In other provinces a considerable amount of exploratory work is necessary before large schemes of tubewell construction can be formulated.

2. These three provinces have several large schemes for exploring ground water by means of tubewells but the actual progress so far has not been upto expectations.

The reasons are :—

(i) Lack of cheap electrical power for working tubewells. Existing electric installations in all the provinces are overloaded and power from any of the large projected hydro-electric schemes is not expected to be available before at least 10 years.

(ii) Reluctance on the part of the provinces to instal steam or oil generating sets for energising tubewells on account of cost. Power from such plants cannot be supplied to cultivators at economic rates without subsidising it. No decision has been taken in any Province in this regard.

(iii) Slow progress in drilling tubewells by means of manual rigs and delay in the supply of power driven drilling plants and other ancillary equipment.

(iv) Non-availability of trained and experienced drilling staff on sanctioned pays both for the purpose of training Indian personnel and for supervising field work on account of which even the available rigs cannot be put to full use.

Unless urgent and immediate steps are taken to remove these bottle necks, satisfactory progress will not be possible. These schemes shown in the list are what the provinces have at present in view. They are however capable of considerable expansion as a result of actual experience on these schemes. The steps which appear to be necessary to expedite the construction programme in the provinces are :—

(a) Including the provinces to allot a definite block of power for tubewell working their existing installations by reallocating existing loads.

(b) If this be not feasible or does not release sufficient power to use steam or oil plants and subsidise the sale of power to cultivators if necessary.

(c) Directives to be issued to the provincial technical officers to formulate tubewell and other pumping scheme to the extent of power made available within a specified time.

(d) To expedite the construction programme so formulated—

(i) To recruit two Drilling Engineers for purposes of imparting training to Indian personnel at the Central Drilling School, Dhanauri. * * *

(ii) Two or three Drilling Engineers to supervise field work in order to expedite construction programme. * * * *

(e) In the alternative to import foreign firms from U.K. or U.S.A. as suggested by Sir Pheroze Kharegat for carrying out tube well construction provided provinces be willing to employ them and to pay the extra cost involved.

4. In any case if the power question could be solved the construction programme can be expedited even by indigenous methods in the absence of power rigs. In the United Provinces 1,500 tubewells were constructed in 5 years by means of hand rigs through departmental and trade channels. It should not be very difficult to repeat the performance in various provinces given the necessary priority in men and materials. At present even the wells already constructed have not yet been energised. Some 25 tubewells were constructed by the C.G.W.O. in Bihar during the past year but not one of them has been so far energised. About 100 tubewells newly constructed in the United Provinces still remain to be energised. In fact during the last Kharif fasl some 300 old tubewells had to be put off for some time for want of power. These provinces are therefore naturally unwilling to push on with their construction programme.

M. C. BIJAWANT,

Irrigation Adviser to the Government of India and Chairman, Central Ground Water Organisation.

Statement showing the position of Tubewell Projects in the Provinces.

Name of Province and Project	No. of tubewells		Estimate		Completed and energised	Remarks
	Standard	Feeder	Sanctioned	Proposal		
EAST PUNJAB						
1. Tubewells in Karnal area.	250	..	..	250	..	
2. Tubewells in Jagadhari.	..	100	..	100	..	
3. Tubewells in Nangal area.	100	..	..	100	..	
4. Private tubewells by Agriculture Department.	2,000	..	..	2,000	..	
UNITED PROVINCES						
5. State Tubewell Scheme Project East and West.	600	..	600	..	411	
6. State Tubewell Scheme (East and West).	250	..	..	250	..	
7. Tubewells in Mainpuri area.	400	..	..	400	..	Explanatory work for this scheme is being taken up.
8. Gorakhpur Tubewell Schemes.	1,000	..	100	900	..	The construction of 100 tubewells is being taken up very shortly.
9. Faizabad Tubewells schemes.	250	..	..	250	..	
10. Gravel packed wells schemes.	..	18	18	..	..	The construction of these tubewells is being taken up shortly.
11. Sarda canal area	..	500	..	500	..	
12. Western canal area	..	500	..	500	..	
13. Private Tubewells Five year scheme (Agriculture Department).	1,000	..	1,000	..	..	Scheme has been received in the G/I for subsidy.
Total o/o ..	5,850	1,113	1,713	5,250	411	

1	2	3	4	5	6	7
Total B/f	5,850	1,113	1,713	5,250	411	
BIHAR						
14. P.B.B.E.B. scheme 7 stage.	60	..	60	..	20	
15. Dehri Sasaram Schemes.	16	..	16	..	16	
16. P.B.B.E.B. Schemes II Stage.	100	..	100	..	..	
17. Gangs and river pumping stations.	..	6	4	2	4	
18. Private Tubewells (Agriculture Department).	250	..	250	..	..	
19. Gaya sugar Mills Ltd.	75	..	75	..	..	
WEST BENGAL						
20. Agriculture Department.	40	..	..	40	..	
ORISSA						
21. State Tubewells scheme.	200	..	40	160	..	Exploration work is to be carried out in the first instance.
MADRAS						
22. Vridhachalam taluks	167	..	..	167	..	
23. Coastal Area	250	..	..	250	..	
CENTRAL GOVERNMENT						
24. Kurkshetra Refugee Camp.	2	..	2	..	..	Construction is in hand.
25. I.A.R.I. Karnal Sub-station.	3	..	3	..	..	Will shortly be taken in hand.
GRAND TOTAL ..	7,013	1,119	2,013	6,119	451	

In addition to the above projects there are several projects for construction of tubewells and exploration of ground water potentialities in C.P. & Berar, Bombay, Palampur, Baroda, Patiala, Dharangdhara and other states.

M. C. BIJAWAT,
Irrigation Adviser, Chairman,
Central Ground Water Organisation.

NEW DELHI,
The 16th March, 1948.

SUBJECT No. 5.—*Consequent on the decision of the country to consider measures to be taken from the short range and long range point of view to maximise the production of food particularly of cereals in India so as to reduce her dependence on imports to the maximum extent possible and to suggest five years targets of increase in such production for each unit of administration comprising India.*

Note by Sardar Bahadur Sardar Harchand Singh, Commissioner for Agriculture, Patiala.

It is an admitted fact that our production is much low than other countries like Egypt, Germany, Japan, U.S.A. and Canada. In my opinion it is mostly due to the following causes :—

1. Seed bed is not prepared as good as it should be, which is due to,
   (a) Poor condition of cattle.
   (b) Poor health of farmers.

When I was young I heard farmers singing a song about the proper preparation of seed bed so that one may enjoy the maximum yield. The song runs as under :—

Sathi sawin gajran sau sawin kamad

Barah sevan payake dekh kanak da jhar.

This means that to prepare a seed bed for carrot crop give 60 ploughings, for sugar cane give 100 ploughings and for wheat give 12 ploughings and then will enjoy the maximum yield.

Similarly they used to say :—

Savan sona har roopa sawan samin

Bhadon wahi gayi nathavi.

It means that if you start the preparation of seed bed in winter (fall) for the coming Rabi crop, you will get the produce equal in gold. If you start ploughing in summer, you will get produce equal in silver and if you will start in July and August produce will be equal to the labour. If you start preparation of seed bed in September and October your labour will be fruitless.

I have put in more than 35 years in this line. I have seen that seed bed is prepared very poorly which is due to the poor health of the livestock. Efforts should therefore be made to improve the live-stock of the country.

The second point of consideration is the poor health of the actual field workers, *i.e.*, farmers. Forty years back in our side of the country, the grown up sons of the farmers used to have wrestling matches and other games daily in the evening. Promising young men were supplied Ghee collectively from the village people but now Ghee and milk is being replaced by tea and vegetable Ghee even in the villages. Formerly farmers never knew what tea is. Drinks were taken on ceremonial occasions, opium was eaten by very few old people but now in the villages opium, drinking, smoking and taking of tea and snuff has become a common habit among the village young men as well as old. They have become unable to put so much manual labour in the fields as farmers used to do thirty or forty years before.

Vast propaganda through the social workers should be carried out to stop these bad habits. We in Patiala State have taken up a group of several villages adjacent to Patiala town to replace the defective poor stock by high yielding

duel breed cows and buffaloes and to arrange to have the maximum yield from the crops in each holding.

2. *Irrigational facilit'es.* (Long term).—In India most of the area depends upon rains. Sometimes, the ra'ns are uncertain. The required water supply of the crops should be arranged by the following methods.

(a) *By digging more canals.*—We are spending extremely little on "AGRICULTURE" as compared with other countries. The work of digging more canals should be taken up by the Government who should be very liberal in spending money for this purpose.

(b) *By constructing "Bundhs".*—In the plains where there are hilly tracts rain water should be collected in big reservoirs by construc'ing Bundhs. This work can be taken up by the Government.

(c) *Construction of masonry wells and Tube wells* (Short term proposal)—Government should be very liberal to g've Takavi (loan) on cheap rates and to arrange the supply of sufficient material for the constructing of masonry and Tube wells.

3. *Low productivity of the so'l.*—It is due to lack of bad preparation of se'd bed as already explained and insufficient supply of manure. To get a proper yield from the soil sufficient quantity of manure should be added. Under the short term the following proposals are put up.

(a) *Farm yard manure* (Short term).—The old and still the best source of supplying organic and inorganic matter is farmyard manure, *i.e.*, the dung and urine of cattle. Lot of improvement can be made in its process by storing in pits. Though a great propaganda has been carried out in this respect, but st'll the Indian farmer is found preparing dung cakes and us'ng it as fuel. It is perhaps due to the fact that dung cakes cost him nothing except his labour and fuel wood is not within his easy reach to obtain In order to discourage burning of dung cakes and using it as a manure quick growing trees should be planted near the villages. Secondly it should be made compulsory by law to store the farm yard manure in pits in which case more than twice the food plant elements w'll be returned to the soil than what it is when it is kept in the open.

(b) *Composting* (short term).—The city refuse can best be util'sed by making its compost. This is another method of adding organic matter to the soil.

(c) *Artificial manures.*—Most of the soils have responded very well to the application of Nitrogenous fert'lizers and their applica'ion should be encouraged more and more. These manures should be made available to the farmers in sufficient quantity near their homes and at cheaper rates. The application of ammonium sulphate does not pay to the cultivator if it is sold at Rs. 11|- per maund to the cultivator when the wheat rate is Rs. 8|8|- per maund.

(d) *Green Manuring.*—Another source of supplying organic matter is through green manuring which is subject to some extent to the availab'l'ty of mo'sture and time required for its decomposition before the next crop is sown. To encourage this organic manure, His Highness' Government, Pat'ala has given considerable concessions in canal water rates.

4. *Double cropping.*—When proper supply of manures will be done, and water supply for crops sufficient and certain there can be double cropping and hence more food.

5. *Supply of sufficient improved seeds.* (Short term).—It can be done by the following methods :—

(a) To lease out large areas for the production of good seed. It is being taken up in Patiala State.

(b) To arrange with big land-lords to grow pure seeds on their farms and to store it for the use of other farmers, in which case Government should pay them the storage expenses and reasonable premium. It is in practice in Patiala State.

(c) To open more agricultural Farms for the production of pure seed.

6. *Bringing of culturable waste under cultivation.*—Under the grow more food campaign we have been able to turn 10,854 acres culturable waste into cultivated area, but the most effective method is that culturable waste belonging to individuals should be opened by means of tractors. Very nominal rates should be charged by the Agriculture Departments. We have this proposal but have not been able to get tractors. The Government of India therefore should arrange to supply tractors to the needy persons at reasonable prices.

7. *Consolidation of holdings.*—Under the long term plan the Government should take up consolidation of holdings vigorously and as quickly as possible.

8. *Soil erosion.*—Due to the faulty methods of land use and certain other factors which are beyond the control of an individual cultivator, millions of tons of fertile soil which is formed during a course of long period is lost through the agency of either wind or water. To check this menace, proper land use planning various engineering and forestry operations should be carried out.

9. *Reasonable price to producer.*—In the end I would strongly recommend that the Government should guarantee a reasonable price before sowing in order to encourage the cultivators to bring more and more area under the price guaranteed crops.

SUBJECT No. V.—*Production of more jute in India in relation to the procurment of food grains from abroad.*

(Note by Dr. B. C. Kundu.)

For the last five years the country has been facing an acute food shortage and the Government of India as also the Provincial Government are doing their best in the matter of production of more food in the country. The food problem has of late been further intensified on of the division of the country.

The question of production of more food is no doubt very important and all our effort must be directed to that direction. From point of view of national self-sufficiency the country must be able to produce enough food to feed her teeming millions. But in spite of all our efforts we are still short of supply of the adequate quantity of food to be required by us.

One aspect of food procurement has not preferably so much discussed and that is how we can get more food from abroad by sending our raw materials and furnished goods which we can import. I am talking particularly of jute. In this short note it will be shown that by sending more jute to outside countries we can get sufficient quantity of food.

The amount of foreign exchange earned by one pound of jute exported and the price paid for one pound of imported food grains.

Jute and jute products are our chief dollar earner, being the leading imports of U.S.A. from India. In 1946 they accounted for 38 per cent. in value of the total U.S. imports from India and earned about 92 million dollars. This more than covered our imports of foodstuffs from the U.S.A. in 1946 which was valued at 74 million dollars. A pound of 9-porter hessian and a pound of raw jute

exported in January 1948 earned 29 cents and 14 cents respectively in U.S. currency, while at that time wheat in U.S.A. was selling at about 5 cents per lb.

The international draft agreement on wheat has fixed the maximum export price of wheat at Rs. 6|11|- per bushel which is equivalent to 1.8 annas per lb. The current price of 9-porter hessian in Calcutta is 13 annas per lb. and that of raw jute 7 annas per lb. The World Wheat Pact is expected to become operative in August 1948. If prices of jute and jute products remain more or less on the same level as at present, then a lb. of 9-porter hessian and a lb. of raw jute will bring us in exchange about 7 and 4 lbs. of wheat respectively.

As regards rice, similar comparison cannot be made for want of price data of countries which supply most of our rice requirements. In the U.S.A., however, rice was selling in September 1947 at 12-5 cents per lb.

From the above data it is seen that it is possible to get more food from abroad if we can export jute for which there is a great market outside.

Requirement of raw jute in Indian Union.—The estimated raw jute requirements of the Indian Union will in the near future be as shown below :—

	Lakhs of bales.
I. Mill consumption	
for manufacturing jute good for export	50
for manufacturing jute good for internal consumption	10
II. Export of raw jute	20
III. Village consumption	1.5
Total ..	81.5
Jute crop of 1947-48 in the Indian Dominion ..	17.0
Deficit ..	64.5

Possibilities of increased production.—The output of jute in the Indian Union can be increased (1) by increasing the yield per acre by the use of seeds of improved strains and by the application of correct fertilisers ; and (2) by increasing the acreage.

Increase in acreage can be effected without increasing the area under food crops. This can be done by (a) utilising small portion of cultureable waste lands and current fallows lying in the jute growing areas ; (b) extending jute cultivation in other provinces and states ; (c) practising a system of double cropping, *i.e.*, growing jute as an earlier additional crop in suitable annam paddy lands ; and (d) providing irrigation facilities in other areas which has proper soil and other conditions but has not the rainfall at the proper season.

It may, therefore, be said that more jute has to be produced in India not only by running the mills but also to get more food as also other capital goods from abroad.

SUBJECT No. 5.—*Increasing food production by controlling plant diseases.*

In any programme to maximise the production of food in India, the destructive role of plant diseases and pests should not be lost sight of or measures to fight them forgotten. A most conservative estimate made some time ago puts the annual loss due to the ravages of rodents, insects, fungi, bacteria and viruses, to the crops in the field and in storage, at 500 crores of rupees and in years when there is a serious epidemic, even of a single disease like the black stem rust epidemic of wheat in 1946-47, the losses will be even greater.

Unfortunately while a good deal of research has been done on fungi, bacteria and viruses at the centre and the provinces, such investigation in a majority of cases have not been integrated to the actual needs of the country. These needs are the estimation of the extent, spread, scatter and relative destructiveness of diseases and development of precise methods of their control. Observations on the growth of a fungus in different culture media, at different temparatures, etc., have their value and while they are important in themselves, they do not tell our farmers what they should do to control the disease which that fungus may cause. While studying a fungus therefore in the laboratory, the methods of controlling it in the field must also be devised.

For each province and state, a list of the *most important diseases* that affect the more important crops must be prepared and the extent of their spread and the damage they cause, determined. These few diseases should be studied from all angles including control methods. Fungi which are scientifically interesting occur on our crop and also wild plants. But the actual damage they do is often very insignificant. Their determination and study should be left to the Systematic Mycologist at the centre or to the University Departments of Botany. To spend the valuable time of the Agricultural Department Mycologists on such matters would be an unpardonable crime.

But the more immediate need to increase food production is to devise quick measures. Among such measures are the treatment of cereal and vegetable seed to control seed borne diseases by seed-dressings and the spraying of vegetable and fruit tree crops by sprays.

The precise extent of some of the cereal diseases that can be controlled by seed treatment is at present unknown. That is because such provinces as West Bengal, Bihar, Orissa, Coorg, Ajmer-Merwara, etc., were without Mycologists until recently and some do not have them even now. In the other provinces the staffs provided to the Mycologists were not commensurate with the needs of the work. But treating cereal and vegetable seed with an organic mercury seed-dressing is, after all, a prophylactic measure, a kind of crop insurance to avoid disease, rather than cure a disease. Seed treated with such a seed-dressing gives, it has been discovered, a more vigorous and sturdy crop which is, it has been even claimed, able to resist to some extent, an air-borne disease that may appear later in the season. Plans should therefore be made to go-ahead with the work of seed treatment.

In the case of the seedling diseases of rice, work done by Gralley, Chilton and their colleagues in the U.S. has shown that greater yields are obtained by treated crops than untreated crops. Uppal and Patel who worked on the *Helminthosporium* foot-rot of rice seedlings at Larkhana in Sind, have shown beyond any doubt that such treatment with organic mercurials controlled the seedling phase of the disease effectively.

Then again the foot-rot of wheat in the seedling phase is prevalent in an alarming degree in the Central Provinces and adjoining States, due to which even the seed-rate is as high as 120 to 130 lbs. per acre. Plans must be devised to

control it by seed-dressings immediately and more work on foot-rot should be planned for our knowledge about it in India is very meagre.

As a result of the work done by the Bombay Department of Agriculture, the use of seed-dressings against jowar smuts has become very popular. The dressing used is sulphur dust of extreme fineness. But sulphur has this disadvantage. that it can control only smuts and not other diseases of jowar that may be prevalent in a province. Tests made in Gwalior and Delhi have also shown that sulphur has a depressing effect on the jowar crop as a whole, so that whatever good it does by controlling smut is lost in other ways. Substitution of sulphur by organic mercury seed-dressings should therefore be encouraged.

Even in the case of diseases that can be controlled by spraying, we do not as yet have any spray-schedules excepting in a very few cases. The attention of the Mycologists has unfortunately been devoted to less important and less urgent matters and the necessity of preparing spray-schedules to fight air-borne diseases has been lost sight of. It is hoped that such schedules to control early and late-blight of potatoes and leaf-spots of other vegetable crops, using Bordeaux Mixture, Dithane or Perenox, would be soon available. We have neglected these matters far too long. It is time something is done, and that too quickly.

B. B. MUNDKUR,

Deputy Director (Plant Diseases),

Directorate of Plant Protection, Quarantine, and Storage.

SUBJECT NO. 5.

IMPERIAL COUNCIL OF AGRICULTURAL RESEARCH.

SEVENTH MEETING OF THE CROPS AND SOILS WING OF THE BOARD OF AGRICULTURE AND ANIMAL HUSBANDRY IN INDIA TO BE HELD IN APRIL 1948.

NOTES ON SUBJECTS ON THE AGENDA PREPARED BY THE BOARD OF REVENUE, MADRAS.

"Consequent on the division of the country, to consider the measures to be taken, from the short range and long range point of view to maximise the production of food particularly of cereals, in India so as to reduce her dependence on imports to the maximum extent possible and to suggest five-year targets of increase in such production for each unit of administration comprising India."

NOTE BY THE BOARD OF REVENUE.

The Development Board, Madras, at its meeting on 18th September 1946, considered it necessary to fix targets of acreage and production in respect of food crops and commercial crops in each district with a view to making this Province economically self-sufficient, particularly in the matter of food crops ; to fix a time limit to achieve self-sufficiency in food and to set up the necessary machinery to assess the achievements each year in each district and in the whole Province ; and to ensure the realization of the targets fixed. This proposal was informally discussed by the Heads of the Agriculture, Land Revenue and Irrigation, and Civil Supplies departments, and it was agreed that the work should be distributed among the three departments and a final report drafted after the detailed reports of the concerned departments were available.

According to the decisions reached at this Conference, the Civil Supplies department has estimated the requirements of foodgrains for consumption excluding requirements of seed and these estimates are furnished in the statement

appended. The estimates are based on the dietetic habits of the people before the war and on the actual consumption during the four-years ending 1941-42 excluding 1938-39 under free trade before conditions became abnormal due to the war. It is based on the formula : consumption = production × imports — exports. In the case of rice and millets, they have been estimated on the basis of average consumption during a period considered as normal after allowing for increase in population and may be considered as fairly accurate.

In the case of wheat and wheat products, however, it will be idle to speculate on future trends of consumption of these commodities. Due to the introduction of controls and subsidies and as a result of the vigorous campaign conducted in the recent past and the comparatively low price at which the commodities were offered through ration shops, the consumption of wheat in eight weeks amounted to nearly as much as the average normal consumption in a whole year before the war. How the consumption of wheat will shape under conditions of free trade is however problematical. The actual offtake for 1946 and 1947 of wheat and wheat products has been furnished and estimates for 1948-56 have been omitted in the statement. It may be taken that the poorer sections of the people will not go in for wheat and that only the richer few will take to wheat to a greater extent than before as their dietetic habits have been transformed to some degree due to the advent of rationing. The consumption of wheat in 1956 may be roughly estimated at about 120,000 tons.

The extent of land likely to be brought under cultivation under existing or sanctioned schemes of irrigation in each of the ten years from 1946 showing uncultivated lands and lands now cultivated with dry crops separately, has been estimated and is shown in the statement appended.

The question of fixing district targets for the next ten years, setting up a machinery to assess the achievements in each year in each district and in the whole Province, and ensuring the realization of the targets fixed and increasing the production with special reference to (a) early sowing of paddy seed beds, (b) improvement of drainage in delta systems and (c) development of mixed farming under wells and in the area to be commanded by the Tungabhadra Project, is under separate consideration by the concerned departments. These are expected to be finalized shortly and a comprehensive scheme as envisaged by the Development Board is expected to be made ready.

In the meanwhile, the Government have formulated a proposal for increasing the production of rice in the Province by an over-all target of 6.5 lakhs annual tons by 1951-52 through several schemes including irrigation and well-sinking schemes. This over-all target is the increase of production aimed at over the average normal production of rice in the Province and has been accepted by the Government of India and is in implementation of the Government of India's Five-year Plan for food production in this Province for 1947-48 to 1951-52 in order to contribute to a target of increased production of four million tons of foodgrains for the whole of India.

The statement below shows the target of 6.5 lakhs tons distributed yearwar :—

Year	Rice in tons.
1947-48	300,074
1948-49	500,000
1949-50	550,000
1950-51	600,000
1951-52	650,000

The several schemes by which the ultimate target of 6.5 lakhs of tons is to be attained and the quantity of paddy which will be contributed by them is furnished below :—

Scheme.	Paddy in tons.
1. Wells—62,500 wells at the rate of 12,500 wells per year—5 acres per well, 25 per cent increase in yield	78,000
2. New private tanks in Malabar and other districts at the rate of 1,000 per annum or 5,000 in five years to command 10,000 acres..	12,500
3. 35 private pumping sets, 1,750 acres at the rate of ½ ton per acre	875
4. 240 P.W.D. minor irrigation projects to command 185,000 acres—1/5 ton per acre being new land	50,000
5. Manuring with (ammonium sulphate) 100,000 tons in fifth year	300,000
6. Manuring with phosphate plus oil cakes or plus green manures : 180·000 tons in the fifth year	180,000
7. Multiplication and distribution of improved seeds for 7,100,000 acres by the fifth year	355,000
	976,375
	other grains in tons
8. Cultivation through mechanical means 75,000 acres in the fifth year ..	13,000
9. Increased yield through contour ridging and levelling 50,000 acres in the fifth year	4,000
	17,000

Total—976,375 tons of paddy or 650,920 tons of rice and 17,000 tons of other grains. The estimated cost of the Five-year Plan is Rs. 8,89,04,900.

APPENDIX I.

Estimates of requirements for consumption excluding requirements of seeds.

Year	Estimated population	Rice	Millets	Wheat and wheat products.	Pulses
Average of 4 years ending 1941-42 excluding 1938-93.	48,041,405	4,885,041	2,858,173	66,050	509,820
1946 ..	52,141,753	1,529,380 (a)	171,374 (a) (b)	206,095 (a)	543,157
1947 ..	52,720,526	1,580,753 (a)	206,090 (a) (b)	38,018 (a)	549,180
1948 ..	53,305,724	5,320,650	3,113,041	..	555,282
1949 ..	53,897,418	5,379,709	3,147,506	..	561,446
1950 ..	54,495,679	5,439,424	3,182,534	..	567,678
1951 ..	55,100,581	5,499,802	3,217,860	..	573,979
1952 ..	55,712,197	5,560,850	3,253,578	..	580,350
1953 ..	56,330,602	5,622,575	3,289,693	..	586,792
1954 ..	56,955,872	5,684,986	3,326,209	..	593,305
1955 ..	57,588,082	5,748,089	3,363,130	..	599,891
1956 ..	58,227,310	5,811,893	3,400,461	..	606,550

(a) These figures represents actual off-take.
(b) Millets include maize, barley, and rye.

APPENDIX II.

Number of the existing or sanctioned schemes	Ayacut fixed under the scheme	Extent now under wet cultivation	Extent likely to be brought under cultivation in 1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	Extent cultivated with dry crops	Extent lying waste
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
VIZAGAPATAM—Nil.														
NOTE.—No existing or sanctioned schemes of irrigation except Ramapadasagar project which is not likely to mature within ten years.														
EAST GODAVARI.														
.. ..	30,[illegible]	—	2,542	2,542	2,542	2,542	2,542	2,542	2,542	2,542	2,542	7,622	..	..
WEST GODAVARI.														
.. ..	7,562·65	618·34	2,816·24	1,139·22	277·65	277·65	277·65	..	..	..	..	..	2,223·23	2,820·29
KISTNA.														
9 —	18,0[illegible]1	—	—	485 (for 3 years)		23·15 (for 2 years)		..	..	..	11,701 (for 5 years)		..	..
GUNTUR.														
1 —	11,288	—	—	..	—	..	..	..	..	..	..	..	850	20
NELLORE.														
(Not given)	625,2[illegible]	..	[illegible]	[illegible]	52,[illegible]	52,526	52,525	52,529	52,529	52,529	52,529	52,526	701,433	763,321
CUDDAPAH. (Not given)														
(Not given)	67,419												149,207	311·94
ANANTAPUR.														
2 —	330	121	17	18	19	20	20	20	21	22	24	27	3[illegible]3	..
KURNOOL.														
7 —	2,532	733	..	..	..	3,553 (for 10 years)		..	..	—	..	..	..	..
BELLARY.														
2 —	..	..	..	820	2,420	2,420	4,220	24,032	37,210	49,124	60,[illegible]	71,559	16,526·17	347,032

						TOR.								
1 –	42	170				30	25	25	20	20	20	16	223	..
						CHINGLEPUT—*Nil.*								
						NORTH ARCOT.								
(Not given)	..	..	10 85	11,403	11,895	12,090	12,340	12,465	12,730	13,310	13,530	13,660	77,795	46,215
						SOUTH ARCOT.								
(Not given)	..	..	8,994	4,965	1,441	163·7	880	844	839	825	600	50	6,921	14,144
						TANJORE.								
2 ..	..	..	432	541	765	809	817	775	775	850	850	850	1,225	6,189
						TRICHINOPOLY.								
3 –	2,009	948	1,061 (for 2 years)		..	..	..	..	..	..	..	1,061	..	..
						RAMNAD—*Nil.*								
						TINNEVELLY—*Nil.*								
						COIMBATORE.								
2 –	1,200	325	..	..	..	875 (for 10 years)	..	..	..	..	..		875	..
						NILGIRIS—*Nil.*								
						SALEM.								
Wells subsidy Scheme	..	..	5 000	..	..	(800 for 2 years)	..	..	..	..	..		1,280,853	739,712
						SOUTH-KANARA—*Nil.*								
						MALABAR—*Nil.*								

MADURA.

Item I.—There is only one existing irrigation scheme, namely, the Periyar scheme in this district. This is a close system and further extension of irrigations is prohibited by the Government. There are no sanctioned schemes of irrigation in the district.

Item II.—As the Periyar system is a closed one and further extension of irrigation is prohibited, the question of uncultivated lands under its ayacut does not arise.

Item III.—(1) All land under the Periyar scheme are cultivated with at least one wet crop in a year. The extent of land under dry crop is therefore nil.

(2) There is a proposal under consideration regarding the issue of temporary or permanent permits for taking Periyar water for about 2,000 acres of hard cases which are on the fringe of the regular ayacut from 1st November every year for cultivating only one crop.

(3) There is also a proposed project, namely, Vaigai reservoir scheme under consideration. If this scheme fructifies on extent of 7,000 acres in Tirumangalam taluk may be expected to be brought under wet cultivation.

APPENDIX VI.

Notes read at the meeting on subject No. 6.

MEASURES ADOPTED TO INCREASE THE FODDER PRODUCTION.

(*L. S. S. Kumar*).

(a) *Selction and propagation of perennial cultivated grasses.*—The perennial grasses cultivated in the different provinces of India, are very few in number and almost all of them are introduced exotics. The principal among the pernnial cultivated grasses of this country are the following :—

Guinea grass—*Panicum maximum.*

Napier or elephant grass—*Pennisetum purpureum.*

Rhodes grass—*Chloris gayana.*

Para or Mauritius water grass—*Brachiara mutica.*

Sudan grass—*Sorghum sudanense.*

Thin Napier grass—*Pennisetum purpureum.*

Guinea and Para grass grow best under irrigated conditions and give good yields. Napier and Rhodes grass are adapted to either irrigated or rained conditions. Sudan grass grows well under rains and tends towards coarseness if grown under irrigation. Thin Napier grass is able to withstand drier and lighter conditions of the soil.

In the Bombay Province the cultivation of perennial grasses is largely confined to Government agricultural cattle breeding and dry-stock farms, government and private dairy farms, municipal effluent farms, and farms under the control of *Goshalas* and *Panjrapoles*. The cultivation of these grasses has not been taken up by individual farmers. If at all it becomes practicable for individual farmers to cultivate perennial grasses, it would of necessity be only possible in the neighbourhood of cities where green fodder would be in continuous demand for salt feeding of livestock or in tracts where cattle breeding and rearing and dairy farming is the main occupation.

In Western India no work has been done so far on selection and improvement of cultivated perennial grasses. Much of the work done in the past has mostly pertained to simple yield trials, time and methods of planting, application of manures, etc. If any work on improvement by selection has been done in other provinces of India, it has not been given publicity. The only instance of an attempt at selection carried out in a perennial cultivated grass in this country is that reported by Narasimhan leading to the selection of thin Napier grass at the Hebbal Farm. This is a selection that has proved suitable for dry and light soil.

The species of perennial grasses that are generally grown in the different tropical and sub-tropical countries are mostly common to each other. In some of these country work on election in the cultivated perennial grasses has been undertaken. Saunders reports of crosses made between Sudan grass and Sorgham at Potchefstroom, S. Africa, from which more leafy, less coarse, high yielding types possessing perennial habit have been selected. In Rhodes grass selections from welfed progeny resistant to frost and those suitable for summer rainfall areas have been made. In Hawaii selection in Sudan grass for high yield and disease resistance is in progress. Selfed strains for resistance to leafspot disease introduced from Wisconsin have proved satisfactory. Leoti-Sudan hybrids introduced from Texas are said to be more resistant to leafspot disease. Merker-Napier hybrids have replaced the susceptible varieties of Nagpier grass of M. Hawaii which is affected by eyespot disease.

In the United States of America Glenn Burton has isolated a few superior strains of Bermuda grass (*Cynodon dactylon* or *doob*) suitable for south esastern regions. Karper and Quinby have bred new varieties of Sudan grass. In breeding selection has been carried out on bluestem grass (*Andropogon furcatus*) by Low and Anderson. These few successful instances show the possibilit'es of breeding better strains of perennial cultivated grasses which have been introduced into India. One of the lines of improvement that could be adopted with advantage in this country is to make a wide collection of different geographical races of the species of perennial cultivated grasses and to carry out selection among them after they become acclimatised in this country.

There are two principal methods by which a large majority of the cultivated grasses are propagated *i.e.* either by seed or by clones. The clonal method is better adapted to planting limited areas. If extensive areas are to be put under the perennial cultivated grasses then sowing seed would be a more practicable measure. Propagation by seed is not as certain as by planting rooted slips, stumps or sets. The experience of growers over a number of years in different countries would indicate that a crop raised from seed takes longer to reach its maximum yield than the one raised by planting clones. Since Guinea, Papier and Para grasses do well only under irrigation, set or slip planting can easily be adopted in their case. Sudan, Rhodes and Thin Napier grasses are best grown with seed sown in rows suitably spaced. It is reported that some of the perennial cultivated grasses fail to set seed in newly introduced places. Therefore, if cultivation on a large scale of such grass is envisaged high seeding quality is an important character to be selected for.

The propagation of selected strains of grasses would depend very largely on the availability of their seed. Therefore in the United States of America considerable importance is attached to the production of seed of grasses and legumes of reliable quality required in the establishment of new pastures or in the renewal of old ones. The enormity of trade in grass and legume seed would be apparent from the following table :—

Clean seed production and price to growers in United States of America in 1942.

Kind of seed.	Amount produced lb.	Pri e in Dollers per 100'lb.
Su 'an grass.	37,300,000	2·60
Rye grass.	33,300,000	5 00
Kentucky grass.	33,162,000	5·60
Doob or Bermuda.	8,65,000	..
Desped za.	135,969,000	5·86
Austrian Wintor pea.	133,300,000	5·00

In 1942 United States of America produced over 37,000,000 lbs. of seed of Sudan grass, 33 million lb. of rye grass and Kentucky blue grass, 865 000 pounds of *hariali* or *doob* grass seed. Among seed of legumes it had produced over 133 million pounds of gespedo and Austrian Winter pea. Besides these, seed of important clovers, of other forage legumes and grasses were produced to the extent of several million pounds. The annual income to the United States of America in grass and legume seed trade runs to millions of dollars. This enormous trade in seed is necessary for the establishment and maintenance of pastures required for the production of beef and dairy cattle.

In this country trade in seed of cultivated crops is yet to be organized. It would therefore cause no surprise, if it is stated that trade in seed of forage crops has not been thought of. If the grasslands of this country are to be put down to better types of grasses and legumes work on selection of superior types of indigenous grasses and legumes should be undertaken and when sufficient number of selected strains become available then the production and multiplication of their seed on a large scale would have to be organised.

(b) *Improvements in rotational grazing.*—The consideration of any improvements in the practice of rotational grazing is only possible when the method has been generally accepted and is practised on a wide scale. It is, therefore, necessary to enquire to what extent rotational grazing has come to be adopted as a permanent measure of grazing in the various provinces of India. Reference to literature on the subject would appear to show that this method of grazing has not been adopted on a large scale anywhere in India as it has not found much favour with the villagers in any of the provinces. In a few provinces, however, this practice has been enforced by the forest departments as an experimental measure. Whether success has attended these measures and helped the forest departments to adopt it on an extensive scale is not known. As far as the Bombay Province is concerned although rotational grazing has passed both the experimental and demonstrational stages, the measure is not popular with the villagers.

Improvements in grazing and of grasslands have been discussed in the past but separately by the agricultural, forest, livestock and revenue departments of each province. Each of these departments have considered the matter as affecting them most with the result that conflicting suggestions have come out of these discussions. It is, therefore, necessary to lay down certain broad principles in regard to grasslands and grazing on which all the departments concerned agree and which would be in the best interest of the nation.

In Bombay Province grazing experiments carried out by the agricultural and forest departments over sufficiently long periods have definitely shown that deteriorated grassland could be rehabilitated by the adoption of rotational grazing and they could be maintained in good condition by continuing the grazing practice. Propaganda made by the forest and agricultural departments for the general adoption of rotational grazing has not met with any success. The villagers are completely averse of introduction of any grazing methods that would affect their existing rights of free and unrestricted grazing. Some years back the forest department of the Bombay Province had adopted the practice of levying grazing fees on animals allowed to graze in forest grasslands. By this measure it was possible to exercise some check, although to a limited extent, on infringement of grazing rights. But now grazing has been made free and unrestricted with the consequent result of endangering grasslands by exposure to destruction of the vegetative cover and soil erosion. Even if grazing is made free, in the interest of the villagers themselves and the nation as a whole it would be necessary to stop unrestricted grazing.

There is urgent need to consider how best to get the villagers to adopt rotational grazing if necessary in as simple a form as possible. Should methods of persuasion or enforcement be adopted ? Persuasion has been tried and has failed so far. In the interest of national economy the time has come for the provincial governments to frame rules to protect grasslands in line with the rules that already exist for the protection of forests. This is the first step in the national conservation of grasslands.

Types of grasslands differ according to differences in physiographic and climatic conditions. It is, therefore, not possible for a uniform method of rotational grazing to be adopted over an entire province. Modifications of the method

to suit different conditions would have to be introduced to suit local conditions. Sagereiya has recommended two alternate plans for making better grazing available in open pasture forests. Garland and Dalley have prepared plans to suit the somewhat differing conditions in West and East Khandesh divisions respectively. Rotational grazing in forest areas has to fit in with the working plans which in its turn is dependent on the nature of the forest. Dalley points out that rotational grazing planned for East Khandesh would not suit the heavy rainfall district of Kanara or the coastal district of Kolaba in the Bombay Province. Similarly the results of experiments carried out by the agricultural department in the dry eastern part of the Poona district receiving scanty rainfall would only be applicable to areas receiving 25 inches or less of rainfall. This would show that sufficient information is not yet available as to the method of rotational grazing suited to heavy and moderately heavy rainfall tracts or to grazing on hills as compared to grazing on plains. Information on these aspects would be necessary if rotational grazing is required to be enforced for adoption in all the villages.

An important aspect of rotational grazing on which information based on experimental data is lacking, is that of carrying capacity of grasslands. In the Bombay Province an arbitrary figure of two acres has been fixed as the area of grassland required per head of cattle. If two acres are sufficient for grazing in the moderate rainfall area, they would be insufficient for the drier regions in which the majority of the grasslands are heavily eroded and support scanty vegetation. Likewise two acres would be more than what is required per animal in the heavy rainfall tract where luxurient growth of grass is available. Unless exact data on carrying capacity of grasslands is available for the different types of grasslands, the number of cattle that could be permitted to graze on each type cannot be determined. Whether a grassland is being over or understocks cannot be estimated without experimental data on the carrying capacity of grasslands.

The immediate requirements in improving grasslands are (1) the adoption of rotational grazing on more extensive scale, (2) the divising of suitable methods of rotational grazing for the different types of grasslands and (3) the determination of the carrying capacity of grasslands. Unless these steps are taken any consideration of improvement in rotational grazing is premature.

(c) *Exploration of new fodder crops in addition to improving existing ones.*—In exploring for new fodder crops greatest success would possibly be obtained from introduction of new types. The United States of America, Great Britain, the Union of Soviet Socialist Republics, New Zealand, Australia and Canada are some of the countries which have benefited considerably from the introduction of foreign species of forage plants and which to-day occupy an important place in the fodder production of these countries. So far as India is concerned no serious attempt has been made at systematic introduction, trial and acclimatization of exotic fodder plants. Many of the perennial cultivated grasses grown at present were introductions of a few decades back and these have become well acclimatized and are an important source of perennial fodder. One of the recent introductions that has proved successful is that of Giant African Star Grass (*Cynodon plectostachyum*). Thus there appears to be sufficient scope left for further introduction of new species.

Sir William Jenkins on his return from a visit to the United States of America brought seeds of a large number of fodder grasses, legumes and dwarf jowars. Trial plantings of these at Poona has shown that some of the grasses and legumes may get acclimatized and prove as suitable introduction into this Province. The

trials on these grasses show that they are not suitable for either the heavy rainfall or the dry precarious rainfall tracts. They have done well in the medium and low rainfall tracts of Belgaum and Poona respectively. A good distribution of rainfall helps in establishing them well. The following is a list of grasses and legumes that give promise of doing well.

Grasses—

Blue Panic grass—*Panicum antidotale.*

Weeping Love grass—*Eragrostis curvula.*

Boer Love grass—*Eragrostis chloremelas.*

Lehmaun Love grass—*Eragrostis Lehmanniana.*

Veldt Love grass—*Eragrostis superba.*

Blue grama—*Bouteloua gracilis.*

Switch grass—*Panicum virgatum.*

Common Bahia—*Paspalum notatum.*

Legumes—

Tropical kundzu—*Pueraria phasieloides.*

Legume for high rainfall—*Centrosema pubesens.*

Hubam Sweet clover—*Melilotus annua.*

The success of an introduced species will depend on its seeding ability. Among the many that have shown good growth only few seed satisfactorily. Again some of the species do not produce any seed in the first year of their introduction but seed well in the next season.

Before the success or failure of introduced species is judged it would be necessary to test them in different places to determine their zonal adaptability. Thus a species unsuccessful in one zone may prove useful in another.

In planning trials of introduced species it would be desirable if material is obtained from those countries which have the same or nearly the same physiographic and climatic conditions of the country or the province in which the trials are to be conducted.

The following is a list of species which it would be worth introducing as they have done well in other sub-tropical and tropical regions :—

Panicum colaratum.

Paspalum malocophyllum.

Desmodium canum.

Indigofera endecaphylla.

Lotus anguistissimus.

Bur clover.

Black medic.

Indian yellow sweet clover.

The Australian Government have recently deputed one of their scientists to accompany an American expedition to South America for the collection of wild varieties of Arachis (groundnut) which may prove of importance and also for collection of suitable pastures grasses and legumes. There are many parts of the tropics and the sub-tropics of the world which remain unexplored. Organization of expedition to these may help in the collection of valuable fodder plants

SUBJECT No. 6.—*Fodder production in India—Note by K. C. Sen and S. C. Ray, Indian Dairy Research Institute, Bangalore.*

1. Fodder grasses which are produced in this country by cultivation are usually the imported ones. The more important amongst them are, (1) Napier grass (*Pennisetum purpureum*), (ii) Guinea grass (*Panicum maximum*), (iii) Rhodes grass (*Chloris gayana*) and (iv) Sudan grass (*Andropogon sorghum*, var, *sudanensis*). Since in practice, the crude protein, lime and phosphate contents generally decide the quality of a green fodder, it would be of interest to consider the average amount of these constituents in the above cultivated fodder grasses. The samples for analysis were taken at the inflorescent stage when the plants are considered most suitable for cutting as green fodder.

TABLE I.

Composition of cultivated fodder grasses in India.

Name	Percentage on dry basis		
	Crude protein	Lime (CaO)	Phosphate (P2O5)
Napier	5·35	0·46	0·80
Guinea	7·97	1·023	0·54
Rhodes	9·36	0·42	0·23
Sudan	5·68	1·19	1·33

The figures in table I show that in protein content, Rhodes grass tops the list and is fairly closely followed by Guinea grass. In Napier and Sudan grass, the protein value is about the same and approximately 40 per cent. lower than that of Rhodes. The lime content of Guinea and Sudan grass is quite high and half time as much as that of Napier and Rhodes. For a green fodder, the lime value in the latter grasses is rather low. Sudan grass is rich in phosphate. A fairly good provision of this constituent is also seen in Napier. In Guinea grass, however, the phosphate value is just on the border line of adequacy, whereas in Rhodes it is definitely low. Taken all the constituents together, Guinea grass seems to commend itself as the most desirable type for selection.

While the distribution of protein, lime and phosphate is considered the criterion for selection, researches carried out in recent years by the authors at Izatnagar have shown that these grass fodders contain oxalate salts; Napier and Guinea grass particularly contain these in fairly large amounts. Total oxalate content (expressed on dry basis as percentage of anhydrous oxalic acid) in the grasses is given in table II.

TABLE II.

Oxalate content in cultivated fodder grasses.

Name	% anhydrous oxalic acid	Relative distribution
Napier	3·30	100
Guinea	2·00	60
Rhodes	0·25	8
Sudan	0·23	7

It is evident from the data in table II that compared to Napier grass, Rhodes and Sudan grass contain negligible amount of oxalic acid and Guinea grass contains about 60 per cent. of that of Napier. The present of large amount of oxalates in a fodder (Paddy straw) low in calcium have been found to exert deleterious influence in the assimilation of calcium and to produce undesirable clinical symptoms. Oxalic acidim Napier and Guinea grass occurs almost to the same extent as in some varieties of paddy straw and although no experimental evidence has yet been collected, it is likely that the same physiological disturbances as are seen in paddy straw feeding, may be produced when these fodders are fed in large amount. There is, however, one compensating aspect with Guinea grass ; its lime content being fairly high (being 2 to 3 times more than either Napier grass or paddy straw) and oxalic acid content being lower, the deleterious influence of the latter may not be very marked. Some experimental evidence should, however, be gathered to substantiate this statement. In view of the fact that oxalates in fodder is susceptible to microbial destruction, a safer way of utilization of these fodders would be by ensilage preparatory to feeding.

Napier grass is now known to give the heaviest yield. In a controlled experiment carried out at Izatnagar, the relative proportion of yield at inflorescence stage was 6 : 4 : 2 for Napier, Guinea and Rhodes grass. When, however, gross and digestible nutrients are taken into account, inspite of its heavier yield, Napier is found to supply only almost as much nutrient as Guinea per acre of the crop.

From the practical stand point of crop husbandry, another aspect, namely, the extent to which the amount of the nutrients would fall with progressive maturity, deserves attention in the selection of these grasses. In table III are shown the protein contents of Napier and Guinea grass at different stages of maturity which speak for themselves. Apart from an early lowering of the protein content, Napier grass becomes thick stemmed and coarse too soon, and it should be considered much inferior to Guinea grass as a fodder for milch cattle.

TABLE III.

Protein content of fodder grasses on progress maturity.

Stage	Napier	Guinea
Prime	5·35	7·56
In flower	3·75	4·76
In seed	2·30	3·50

Lately, attention has been focussed on the possibility of cultivating some of the indigenous grasses in the *barani* waste land. In this connection, the report by Hussain* (1946) of results of a 4-year trial of comparative yield of five indigenous grasses, *viz.*, Jenewah (*Andropogon ischamum*), Golden crown (*Paspalum dilatatum*), Kolukattai (*Pennisetum cenchroides*), Bhanjura (*Apluda varia*) and Surwala (*Andropogon contortus*) and three cultivated grasses, *viz.*, Napier, Guinea and Rhodes are of interest. In so far as the yield is concerned, the cultivated grasses like Napier and Guinea excel the indigenous species. But when viewed from such consideration as (a) cost, labour and organisation involved in the production (b) the number of effective channel of disposal, indigenous species may prove to possess special advantages in the future programme of fodder production in *barani* lands.

* Production of fodder grasses in India ' by M. F. Hussain (1946), Indian Farming, 7, 176.

In selecting the suitable grasses for propagation considerable amount of agronomical research has yet to be made to decide (a) the regional suitability of species (b) relative response to fertilization and cultural improvement and (c) the duration of stand and susceptibilities to extraneous environmental conditions, such as, drought, excessive rain, etc.

II. Grass land in the Western sense is almost non-existent in India. The available grazing is essentially confined to the so-called waste lands. In the forest area, about 80,000 square miles are open to grazing, but the number of animals which actually take advantage of forest grazing is only a small fraction of the total population. The remoteness of forest grass lands from the human habitation is a serious obstacle for the utilization of a vast source of fodder. Any extensive use of cut grasses from the interior of the forest area is also precluded by transport difficulties. In view, however, of the acute shortage in fodder supply, every effort should be made to mobilise this source. Necessary roads may be constructed and an organization may be set up by the Government to cut this grass and turn it into hay to facilitate conveyance to the consuming centres.

Although forest grazing does not provide for a larger number of animals, an intensive grazing, however, occurs in certain areas and in the outer fringes of most of the forest belt. As a result of indiscriminate and over-grazing, the vegetation is ruined leading to considerable erosion of the soil and barrenness of the tracts. Similar observations have been made on the effect of over-grazing in the Indian plains. Plans of reclamation of the eroded area are now being actively considered. But in order to obtain quick results, legislative measures for controlled grazing is called forth for immediate adoption. The control on over-grazing has to be based on scientific principles of grassland management. The topography, the type of soil, local climate, the nature and distribution of grass species, etc., should largely decide the carrying capacity of an area for a definite period. As soon as the period is over, the stock should be withdrawn and turned into a fresh area. The units should be clearly demarcated and suitably fenced off. The success of this rotational system of grazing will largely depend on strict supervision, knowledge and sense of value on the part of stock keepers themselves.

While the introduction of the control is an immediate necessity, agrostological investigation should simultaneously be taken up to study the grass species, their distribution, physiology of growth and maturity, tenacity of establishment, yield and chemical composition. These investigations will offer valuable information in laying the future lines of grassland improvement, particularly in the propagation of the desirable species and eradicating the undesirables. Such investigations, in limited measures, have already been taken up in the provinces and in the centre both independently and under the auspices of the Indian Council of Agricultural Research. The results obtained are not yet sufficiently comprehensive for and detailed discussion at this stage. Data are, however, available which go to show that :—

(a) Compared to perennial, the annual grasses generally reach maturity quicker and are more susceptible to abnormal changes in the environmental conditions. Although some of the annuals are fairly heavy yielders, the accelerated vegetative growth make them more fibrous and poorer in nutritive constituents.

(b) Based on prolonged period of vegetative life and chemical composition, indigenous perennial grasses, such as, Anjan or Kolukattai (*Pennisetum cenchroides*); Palwan or Zinzo (*Andropogon annulatus*), Choti jargi (*Bothriochloa pertusa*), Musel (*Iscilima laxum*), Murjhana (*Eremapogon faveolatus*), Goria (Chrysopogon montanus) and Dhub (*Cynodon dactylon*) are suitable for selection and reseeding.

There is one aspect of grass farming to which attention must be drawn. Most of the indigenous grasses become very fibrous and lose much of their nutrients if they are harvested late and made into hay. Apart from earlier harvesting, the possibility of growing some kind of leguminous crop along with the grass so as to produce a mixed hay which will have a higher protein value should be considered. In some area, namely in the banks of ponds and tank beds, it has been possible to grow *Cynodon dactylon* and *Mitti* kalai (*phascolus munge*) together in certain seasons which provide highly nutritious fodder for milch cattle. The so-called meadow hay in United Kingdom contains a good proportion of clover, while in United States of America, a mixed hay containing alfalfa is common.

III. Existing fodder crops other than grasses which have proved important are :—

Legume.	*Non-legume.*
(a) Berseem.	(a) Maize.
(b) Lucerne.	(b) Jowar.
(c) Cowpea.	

At present the quantity of fodder crops produced is very low. Where the number of cattle per acre of cultivated fodder crop should be 2 to 3, there are anything between 9 to 126 in the provinces other than the Punjab and Bombay. Apparently, considerable effort is called for to improve the quantitative production. The increase in production can be achieved by improving the methods of agriculture, such as, application of fertilizers and manures, introduction of suitable crop rotation and cultural methods, evolving better yielding and specific fodder strains, etc. In this connection, the breeding of suitable varieties of fodder Jowar and Maize should be considered. The major quantity of fodder production, however, will require extra allocation of land for the purpose and this can come (a) at the expense of acreage now devoted for food and non-food cash crop and (b) by bringing additional land under cultivation.

While the improvement of quantitative and qualitative production of existing fodder crop is an urgent necessity, efforts should also be directed to explore the possibility of introducing new fodder crops which may be indigenous or imported from abroad. Most of our non-legume fodder crops are low in protein. In recent years, an Australian plant, Kale (*Brassica olercea*, var. *acephala*) has found favour in United Kingdom as a high protein (about 11 per cent.) fodder crop. It would be desirable to find out if Kale could be grown in India as a Rabi crop. Mention may also be made of Giant Star grass (*Cynodon Plectostachyum*) recommended by Sen* (1942). The work at Izatnagar has shown that even at a fairly mature stage, the hay prepared from this grass is palatable and quite nutritious. Investigation has also been carried out to study the composition and nutritive value of tree leaves with a view to using these as fodders. The results collected so far show that leaves of several species of tree, *viz.*, Neem (*Azadirchta indica*), Pipal (*Ficus religiona*), Paker (*Ficus infectoria*), Wild Ber (*Zizyphus jujuba*), Shisham (*Dalbergia sisso*), Jaman (*Engenia jambolena*), Aam (*Mangeferus indica*), Imli (*Tamarindus indica*) and Bans (*Bamboosae indica*), are fairly rich in nutrients. The composition of some almost resembles that of leguminous forage. Later works have, however, shown that inspite of richness in nutrients, the digestibility of tree leaves is generally low and as such their intrinsic food value is not in any way higher than the usual non-leguminous fodders. The excessive distribution of lime over phosphate, low digestibility of protein, the presence in some

*Sen, B. (1942). Indian Fmg., 3, 421.

species of abnormal quantity of oxalic acid and above all, the relatively lower palatibility than the ordinary fodders are factors which may stand against the extensive use of tree leaves in cattle feeding.

In addition to the above, recent reports suggest that Ulu (*Imperata arundenacea*) grass and the aquatic grass Dal (*Hymenchne pseudo-interrupta*) in Assam may be of considerable value as fodder. The Physiological Chemist in Assam has obtained good quality hay from these grasses.

SUBJECT No. 6.—*Methods to increase the fodder production.*

In India a constant supply of good food for cattle is of the first importance. The facts regarding the habitat, life history, chemical composition and the feeding value of the grasses must be ascertained. Grass improvement stations to carry out fundamental researches with the agronomic and other characteristics of grass-legume in relation to yield nutrients, must be started.

Real success in fodder growing depends very largely on a knowledge of morphology and physiology of the plants which leads to the selection of suitable types for different soils.

The fodder production can be increased by—

(1) A systematic survey should be undertaken and promising grasses collected from different parts. These grasses must be tested in all the stations and suitable ones have to be selected from the promising ones.

(2) A detailed study of the selected types should be made for their variability, yield, drought resistance, disease resistance, etc.

(3) Selection of desirable types for high yield and nutritive value must be done by breeding methods as in crops.

(4) Study of grasses in mixtures for determining the best types for pastures.

(5) Selection of suitable indigenous wild legumes to be grown mixed with grasses for increasing feeding value.

(6) Collection and trial of exotic legumes and fodder grasses.

(7) As yet there exists no organization for collection and sale of seeds of wild fodder plants. Seeds and slips of promising and tried ones should be supplied to enterprising ryots for popularising and giving wider publicity.

S. N. CHANDRASEKHARAN,
Systematic and Lecturing Botanist.

MADRAS AGRICULTURAL DEPARTMENT,
10*th December* 1947.

GRAZING PROBLEMS IN THE SUB-MARGINAL LANDS

BY

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"Summary : Figures are quoted to show that there is an over-all shortage of 246 per cent. in the annual availability of concentrates for cattle in India. Similar shortage of production in roughage is 49.69 mill. tons, or about 28.5 per cent. of the present availability. The quickest way of increasing more roughage for the cattle seems to be a proper management of sub-marginal lands, which are defined, for production of fodder ; this is also likely to reduce both sheet and gully erosion as well. The respective responsibilities of the Indian Parliament and the State Legislatures are analysed in respect of land-use legislation, quoting the position in the U.S.A. ; as soil conservation is a matter of national interest, the responsibility of the Indian Parliament is very clear under the Draft Constitution of India, 1948. Land-use classes by slopes are suggested as a rough guide, for reserving 0 to 15 per cent. slopes for agriculture, 16 to 30 per cent. for grazing, and above 30 per cent. for forests. Four methods of improving sub-marginal lands are broadly referred to, which will, not only increase availability of fodder, but also reduce soil erosion, at present rampant in the country.—*Author* ".

Improvement in the quality and health of live-stock in India is admittedly essential for the agricultural prosperity of the country. On the capacity of plough-cattle depends the efficiency of cultivation. About 840 million tons of cattle manure (green) is produced annually by Indian cattle, out of which about 33 per cent. or 280 million tons is estimated to be available for use as (green) farm yard manure, or roughly 1 ton per acre of cultivated land, the rest is either lost or burnt as fuel. Farmyard manure when it is not burnt, but used in the fields, adds to the increased fertility of the soil leading to an increased production of food crops. In improving the nutritive diet of the people an increase in the consumption of milk is the first step. In India roughly about 6.42 oz. of milk is produced per day per head of population while 8 oz. is the optimum. Generally speaking, therefore, on the health and quality of the cattle depends the health and prosperity of the Indian agricultural community.

2. In 1920 the first all-India census of live-stock was undertaken. Since then five-yearly census figures are available. Table I shows the variation of live-stock in India since 1925.

TABLE I.

Province	Number of cattle and buffaloes (in '000s)			
	1925	1930	1935	1940
Assam	5,786	5,662	5,982	6,496
Bengal	25,402	25,402	25,287	23,699
Bihar	20,728	21,308	21,308	15,456
Orissa	..	..	..	4,803
Bombay	8,481	9.416	9,961	9,734
Sind	2,327	2,379	2,635	2,376
C. P. & Berar	11,671	14,378	13,844	13,279
Madras	22,111	22,441	24,607	22,119
Punjab	15,232	14,293	15,841	15,414
United Provinces	31.046	31,460	32,460	32.469
N. W. Province	1,091	1,024	1,038	1,033
Total (Br. India excluding minor administrations)	144,705	148.361	153,745	147,424

3. The figures are incomplete in respect of some provinces and there are considerable errors ot enumeration ; no definite conclusions are therefore possible ; but the table shows the general tendency of an increase in number, between 1925 and 1935 and a decrease later during the 30's, when there was an agricultural slump. It may be assumed that the present number of live-stock in India is roughly 150,000,000 (including Pakistan).

4. In 1937, Dr. N. C. Wright examined the question of the improvement in the live-stock in India ; before him the problem was thoroughly examined by the Royal Commission on Agriculture in 1928. The first action proposed by both was an improvement in the present methods of breeding by providing an adequate number of bulls of improved variety.

5. The question of appropriate and adequate feeding is admittedly more important than even breeding,—for deterioration occurs even in improved breeds without adequate feeding. Dr. Burns analyses the relative importance of different methods of increasing milk production as follows :—Feeding 30 per cent. ; Breeding 15 per cent. ; Management 15 per cent. ; and disease control 15 per cent. Assuming that the average live weight of cattle is 600 lbs., the daily requirements of dry matter per head will be about 13.75 lbs., out of which at least 0.75 lbs. per head per day should be provided in the form of concentrates, and the rest in the form of roughages. The total annual production of concentrates (*e.g.* seeds, oil cakes, bran, and pollard) in India is estimated to be 3.7 million tons, while the estimated annual requirement is 12.8 million tons, leaving an annual deficiency of 9.1 million tons or about 246 per cent. of the annual production. This figure, though not accurate, shows the magnitude of the problem to be faced if the existing live-stock population has to be properly fed.

6. The deficiency is equally serious in the supply of roughages. Table II shows the deficiency of roughages calculated by Dr. Burns by regions. His Region I consists of areas with rainfall over 70″ and comprises the whole of Bengal, Assam, and Coorg, and the western, coastal strips of Madras and Bombay. His Region II has a rainfall of 30″—70″ and includes the whole of Bihar, Orissa, Central Provinces and United Provinces, and portions of Madras and Bombay. In Region III, there is less than 30″ of rainfall, and it covers the whole of the Punjab, North Western Frontier Province, Sind, Baluchistan, Ajmer-Merwara and Delhi, and portions of Madras and Bombay.

TABLE II.

Region	Total bovine adults (million)	Roughages produced annually				Roughages required annually in million tons dry	Deficiency	
		Special fodder crops (Million tons dry)	Straws (Million tons dry)	Grasses (Million tons dry)	Total (Million tons dry		In million tons dry	Percentage of Col 6 upon Col. 7.
1	2	3	4	5	6	7	8	9
I ..	25·8	0·91	16·1	13·85	30·86	46·24	—15·38	67
II ..	61·5	5·84	48·3	41·21	95·35	130·26	—34·91	74
III ..	19·5	12·78	22·8	12·68	48·26	47·66	+ 0·60	103
Total ..	106·8	19·53	87·2	67·74	174·47	221·16	—49·69	72

It will be noticed that of the total deficiency of about 49.69 million tons, it is very heavy in Region II, heavy in Region I, and Nil in Region III, or very dry areas, which now mostly form part of Pakistan. All proposals for land utilization should therefore take into consideration this heavy deficit of roughage in almost every region of India. It is necessary either to produce an additional 49.69 million tons of roughages, which is 28.5 per cent. of the total availability of roughages, or no improvement of the condition of the existing number of livestock is possible.

7. Special fodder crops contribute about 11.2 per cent. of the total annual availability of roughages. About 10.6 million acres were sown with fodder crops in 1942-43 out of which about 5.2 million acres was in Punjab & Sind, 2.6 in Bombay, 1.6 in the U.P., and the rest over other provinces in India. The total net area sown was about 215.9 million acres. Extensive production of such special fodder crops was, however, confined to regions that have since been transferred to Pakistan. (Russell in 1937 calculated that of the total area sown, about 16.1 7.6, 3.2 & 1.7 per cent. was under fodder crops in the Punjab, Bombay, United Provinces, and Central Provinces, respectively). Any large increase in production by increase of area under fodder crops is therefore likely to be slow. But attempts must be continued, without infringing upon the period and area of production of agricultural crops, to get as much special fodder crops as is possible, suitable for the climate and soil, of the regions. In the case of straw, however, with an increase in area under food crops such as rice, wheat, and millets due to the present drive in "grow more food" campaign, there is likely to be a parellel increase in the availability of roughages from straw, which is responsible for almost exactly 50 per cent. of the total supply.

8. Grass contributes the next important quota (about 38.8 per cent.) of roughages, and any slight percentage improvement in the yield of grass will add considerably to the total availability of roughages. Grazing areas supplying grasses fall under two main groups : Forests, and cultivable waste. Table III below, according to Sir C. G. TREVOR in 1937, shows that *"Forests are on'y of minor importance as grazing grounds* ; for, only about 10 per cent. of the cattle of the five Provinces possessing large areas of foreign had access to forest grazing. As large areas in Reserve Forests are inaccessible, the intensity of grazing shown in Col. 5 of Table III tends to indicate a better situation than what it actually is in the nearby accessible, and intensity grazed localities. Intensities of grazing on an area can be said to vary inversely as the distance of the area from the nearest cattle-pen. It is therefore twice as heavy on an area situated at half the distance of another area.

TABLE III.

Provinces	Forest Grazing				Non-Forest Grazing		
	Area of Forest (Sq. miles)	Area of forests open to grazing (sq. miles	Live stock utilizing* forest areas (in millions)	Intensity of grazing (acres/ head)	Live-stock (in millions)	Area avail-able (Sq. miles)	Intensity of grazing (Acres/ head)
United Provinces	6,000	4,000	1·3	2	42	31,000	0·47
Madras	16,000	14,000	2·2	4	41·3	51,000	0·79
Punjab	5,200	4,700	2·7	1·51	23	22,000	1·17
Central Provinces ..	19,400	17,000	3·1	3·5	13·1	30,000	1·46
Bombay	14,000	12,400	2·4	3·25	11·5	40,000	2·22
Total ..	60,000	52,100	11·8	2·8	130·9	91·000	0 95

(*Intensity of grazing is defined by the area in acres available for grazing per head of livestock populations.

9. Forest grazing is under the control of the Forest Departments of the different Provinces, and is generally regulated by the issue of grazing licenses, at a nominal annual fee, for grazing in blocks in Reserved Forests. Where the control of certain easily accessible forests has been handed over to a "panchayat", there has been unrestricted grazing, and consequent deterioration of the area as a potential source of fodder and fuel supply. Sheet and gully erosion has been noticed extensively over such overgrazed panchayat forests. The fertile top soil has been removed, which makes it more difficult to improve the present conditions of the growing stock of both trees and fodder grasses.

10. It is, however, in areas outside the reserve forests, and situated between them and the intensively cultivated agricultural lands that one must search for this potential source of increased supply of fodder. These are broadly called "cultivable waste" or "submarginal lands", which it is uneconomical to bring under plough under normal conditions of agricultural prices. Portions of these lands are cultivated for a year or two when the agricultural prices are high, or the intensive drive of the Government under "grow more food campaign" attracts the cultivator to take an additional amount of trouble to bring sub-marginal lands under cultivation. Such lands, generally revert to their original status of "cultivable waste" after a few years. The concept of "sub-marginal" lands includes lands that, if cultivated, would make erosion practically uncontrollable, unless costly anti-erosional measures are first applied on them.

11. According to the Agricultural Statistics of British India 1942-43, there are about 91,889,000 acres of uncultivated land excluding current fallows, which are generally used as grazing ground. Table IV shows the classification of area in India.

TABLE IV.

Classification of area in India by land uses.

Serial No.	Classification	Area (1,000 acres)	Percentage of total
	Area by professional survey	514,104	100
	Area according to village papers	513,277	..
1	Area under forests	68,153	13·2
2	Area not available for cultivation	90,580	17·6
3	Other uncultivated land excluding current fallows ..	91,889	17·9
4	Fallow land	45,882	8·9
5	Net area sown	215,928	42·0
6	Irrigated area	55,734	10·8

12. Not only for the increased production of fodder, which itself is a sufficiently important justification, but also from the standpoint of soil conservation, these sub-marginal lands require immediate attention. Uncontrolled grazing and unchecked cutting of timber from these lands is a serious matter because the mischief is not immediately obvious. A casual inspection of some of these "waste"

lands will show frequent occurrence of sheet and gully erosion in varying degrees of intensity. In some cases the gullies have become deep ravines. The regions that require immediate attention can be roughly enumerated as follows :—

(1) Narbada Valley between Hoshangabad and Jubbulpore. Roughly an area of about 200 square miles of good black-cotton soil has been broken up into deep ravines due to denudation, excessive grazing, and absence of any soil conservational methods in the systems of agriculture.

(2) Areas in the Chambal and the Jumna basins where ravine erosion is frequent.

(3) Undulating districts in western Bengal where sheet erosion is common due to excessive grazing and denudation.

(4) The 'problem' districts of Bombay, such as sholapur, Bijapur, and Dharwar where sheet erosion is abundant.

(5) The upper regions of the Mahanadi Valley in the Central Provinces.

(6) The Ceded Districts of Madras.

(7) Steep slopes of the Himalayan valleys in the Kosi catchment area in Nepal.

13. While the forest lands under the control of the Forest Departments are being carefully conserved by technically trained men of the Forest Departments in the different Provinces, and the agricultural lands are being looked after by the agriculturists themselves with the advice of the Agricultural Department, there is no authority to think about and to take charge of these sub-marginal lands which are deteriorating rapidly. In a comprehensive plan for land-utilisation in India an appropriate system of management for these lands assumes great importance due, firstly, to the possibility of an increase of fodder and fuel from these lands, and secondly, to the necessity for control of rampant soil erosion which is constantly destroying our national wealth in lands. The direct effect of this excessive accelerated erosion is loss of fertility of the agricultural soil, waste of runoff in high floods, silting of river channels, frequency of high floods, meandering of river channels, increasing height of high floods, and increase of drought.

14. Under item 32 of List I of the 7th Schedule of the Draft Constitution of India (1948), shipping and navigation on Inland Waterways, declared by Parliament, by law, to be national waterways, as regards mechanically propelled vessels, is in the Union list ; *i.e.*, the Indian Parliament under Section 217 has exclusive power to make laws with respect to this item. Similarly, under item 74 of List I of the 7th Schedule of the Draft Constitution of India (1948) the development of inter-State waterways for purposes of flood control, irrigation, navigation and hydro-electric power is also an Union item. Though water, agriculture, lands, and forests are included in items 20, 21, 24 and 27 of List II (State List) of the 7th Schedule of the Draft Constitution of India, (1948) under Section 226 of the Draft Constitution of India, (1948), the Parliament has power to legislate with respect to a matter in the State List in the national interest. Conservation of soil is a matter of national interest and has been admitted to be such in the United States of America in the Federal Programme of agricultural adjustment. It is therefore desirable that the Union Government of India gives a lead to the States in respect of legislation on conservation of soil in all lands, *including focal points of erosion in sub-marginal lands.* This action is likely to increase production of fuel and fodder for the villagers, as its direct result.

15. The history of soil conservation operations in the United States of America, pioneer in this field, would perhaps be relevant for our purposes. The Congress of the United States of America, in an Act approved in April 1935, directed the Secretary of Agriculture to establish a Soil Conservation Service in the Department of Agriculture, to conduct a comprehensive national programme of control of soil erosion. Under this statute the Soil Conservation Service opened and operated hundreds of demonstration areas in many States, directed the work of Civilian Conservation Corps camps, and conducted co-operative erosion-control studies at many agricultural experiment stations. It was soon realised, however, that the problem of erosion could not be solved adequately by work in isolated areas alone, and immediate necessity was felt for *State Legislation by which the farmers could organise themselves for co-operative action*, to apply on their lands the erosion-control practice that they observed on the demonstration projects of the Soil Conservation Service. Accordingly the Congress authorised the Secretary of Agriculture to require the adoption of suitable *state legislation* as a condition of his spending federal money in any State for erosion-control work. Under this provision the Department of Agriculture prepared the State Soil Conservation Districts Law, which President Roosevelt recommended to the 48 State Governors for submission to their respective State Legislature in 1937. Immediately, in 23 States legislation was adopted more or less along the lines of the standard Act. However, in Montanna, Minnesota, North Dakota, and Nebraska the Acts, as adopted by their State Legislatures, do not make adequate provision for enforcement of land-use regulations. In order to avoid the pitfalls encountered in the United States of America, it would be desirable to have the Indian Parliament consider from the outset the desirability of having uniform States legislation in the different Provinces for anti-erosional and land improvement measures.

16. Appropriate State legislation in all Provinces on the lines of Bombay Land Improvement Schemes Act, 1942, and the Punjab Land Preservation (Chos) Act of 1900 would be desirable. It is only when powers are given to officers or associations by legislation that any progressive planning of land utilisation could be taken.

17. In formulating the main principles of land-utilisation in India the gradient, or the slope, of the land can be taken initially as a rough guide. There is generally a correlation between the percentage of erosion and the gradient of the land for different land-use classes, provided the erodibility of the soil is not widely different. The effect of the slopes on erosion in the watershed of the Norris Dam in the Tennessee Valley is shown in Table V below :—

TABLE V.

Land use classes	Percentage of erosion for stores		
	Gentle (0—15%)	Moderate (16—30%)	Steep over 30%
Crops	15	29	31
Idle & abandoned land	5	26	36
Pasture	15	22½	26
Forest	0	5½	7

18. In the United States of America it has been seen that for normal conditions of cultivation, the gradient of the maximum slope that could be allowed depends upon the local soil and climatic conditions. While in some places it may exceed 5 per cent. in others not more than 2 per cent. could be allowed. Even in these cases of very gentle slopes it would be desirable to introduce principles of soil conservation in cultivation methods, such as contour cultivation, strip cropping, and rotation of crops. Above 5 per cent. and upto about 15 per cent. gradient, cultivation can be allowed only with effective anti-erosional measures, such as graded terraces with appropriate outfalls either of the absorbent or channel type, with contour cultivation and strip-cropping.

19. Bennett has stated that come soils could be cultivated with a fair degree of safety on slopes having a gradient of about 20 per cent. specially in porous gravely soils. On the other hand one or two per cent. gradient is stated to cause appreciable erosion in Knox silt looms. These distinctions with regard to slopes are therefore not sacrosanct. These should be applied with local variations. As a general rule we may expect that all lands with a gradient more than 30 per cent. should be under forests, with controlled grazing ; such control may be applied in restricting the number of cattle to the limit of grazing possibility, or by rotational grazing to provide short period of rest for portions of the year to allow seeding of good fodder grasses, or by setting apart areas for grass cutting. Such areas may be constituted into reserve forests, if of sufficient extent, or village forests, according to situation, for the supply of fuel and fodder to the neighbouring villages.

20. Areas in sub-marginal lands with moderate slopes that is 16—30 per cent. may generally be considered, maintained, and managed as grazing grounds with appropriate anti-erosional measures All steps necessary to increase the production of fodder from such sub-marginal lands will have to be taken when appropriate legislation is passed by the State Legislatures.

21. In improving the grazing conditions in these sub-marginal lands with a slope of between 16—30 per cent. we may follow the methods in Montanna, United States of America where 'co-operative grazing associations' have been organised under State Legislation. These associations are set up under an Act which states that their primary purpose is to be the conservation and improvement of grazing lands. Co-operative operation in the use of grazing lands of the area creates a mutual interest in improved management, and the association, through its business organisation, is in a stronger position to use legal means to combat trespass than is the individual.

22. The actual steps necessary for improving pastures on sub-marginal land are not difficult to suggest. There have been many experiments in different parts of India at different times. The first step will probably be an effective control of grazing over selected areas in the sub-marginal lands. It has been found that a full closure to grazing is also an effective check on erosion, and more closure for a few years results in a profuse natural growth of grass quickly covering the soil in most places, as the first stage towards rehabilitation of the vegetatvie cover. This increase of the grass cover is responsible for stopping further accelerated erosion and reduction of runoff. It has been reported that in the Pabbi tract, the reclamation area of about 3,000 acres yielded a revenue of a rupee per acre for grass cutting in 1937, as compared with a grazing revenue of 1½ annas per acre for adjoining lands. The application of strict closure on all lands however is not immediately possible. After an initial period of closure the area could reopened to a restricted grazing ; otherwise, it has been seen in the United Provinces that worthless grasses like *Aristida Hystrix* and *Aristida depressa* invades the land to the complete disappearance of useful fodder grasses.

23. The second method of improvement of grazing in sub-marginal land may be by controlled grazing. This control means :—

(i) restriction of the number of cattle to be allowed in the area to the limit of grazing possibility.

(ii) Rotational grazing to provide short periods of rest for portions of the area, and time to allow seeding for good fodder grasses. Periodical grazing in which long periods of rest alternate with comparatively long periods of grazing is also a suitable form of control in some localities.

(iii) Setting apart areas for grass cutting to tide over the long dry season.

(iv) Restriction of goat grazing and exclusion of goats from hill slopes.

24. The third method of improving sub-marginal lands may be by countour-trenching and contour furrowings. Contour trenches are intended to create favourable moisture conditions in the soil to hasten the restoration of the plant cover and to help establishment of new tree species. Large areas of sub-marginal lands have been impoved in Bijapur, Sholapur, and Dharwar districts of Bombay by contour trenches. Not only has good fodder grasses appeared due to increased moisture and restriction of grazing, but also the annual yield of grasses from such areas has increased ; the freshly introduced tree species, such as *Neem, Cashewnut, Hardwickia binata* and *Cassia Siamia*, etc., with which the area has been planted will afford fuel, fruit, and small timber to the villagers in due course. Along with contour trenches, the existing gully erosion could be controlled by check-dams and the standard gully-plugging methods, devised in the Pabbi Reclamation area. The effect of contour trenching and gully-plugging upon reducing the runoff, and therefore controlling the flood, has been noticed both in the United States of America and in the Punjab.

The last and the final method of improving grass land will be by stocking the pasture with better fodder grasses and forage. Considerable study and experiments are still required to discover a correct grass-legume mixture for pasturage under Indian soil and climatic conditions. Pasture grasses require a light loamy soil fairly well provided with manurial ingredients. They thrive best under an equable climate with frequent light showers well distributed throughout the year. Such ideal conditions are rare to find in India. Here experiments are to be conducted in search of drought-resisting fodder grasses.

26. In South India, the Kollukottai grass (*Pennisetum cenchroides*) has been found to be one of the best in composition, with rich herbage. Amongst exotic grasses, the Government farms have popularized the *Guinea grass*, a native of tropical Africa, and *Elephant grass*. The land requires a good dose of cattle manure before planting out. *Guinea grass* is palatable to cattle, is highly nutritious, and yields about 30,000 to 50,000 lbs. per acre, while *Elephant grass*, on the average, gives 60,000 to 90,000 lbs. of fodder per acre. *Lucerne* or *alfalfa* (*Medicago sativa*) has been grown widely in western India for its protein-rich roughage. The crop requires manuring, as well as irrigation, and is expected to yield 50,000 to 60,000 lbs. per acre, though much higher yield has been recorded under optimum conditions.

27. From the point of view of erosion-resisting qualities the following species may be mentioned in order of merit, as found in the United States of America.

(1) Bermuda grass (*Cynodon dactylon*).

(2) Lespedeza grass (*Lespedeza sericia, Istriata, L. Stipulata*).

(3) Clovers (*Trifolium spp*). } Leguminous fodder.
(4) Cowpeas (*Vignia sivensis*). }

(5) Alfalfa grass. (*Medicago sativa*).

Kudzu Vine, a native of China, has also been found very effective in resisting erosion besides supplying profuse quantity of fodder. It grows prolifically and runners frequently attain 30 ft. in one season. It may be locally suitable species to grow under favourable conditions.

28. The report on soil-erosion in India by Dr. D. V. Shuhart gives a brief general idea of the extent of the problem in the country and the urgency of action to be taken. While his report deals with all lands, the present paper is confined mainly to the action to be taken in sub-marginal lands. If the steps suggested in this note are taken, not only will soil erosion be controlled but also there will be an appreciable increase in the availability of fodder and roughages for the existing number of live-stock in India. It is only when all the lands in India are producing to their maximum, and every square yard of ground is doing its duty of producing either an agricultural crop or a forest crop or fodder, and there is no further possibility of increasing the available fodder in the country, that we could think of reducing the number of cattle, economic or uneconomic, a thought repugnant to millions of Indians.

SUBJECT No. 6.—*To review the measures adopted to increase the fodder production by* :—

(a) Selection and propagation of perennial cultivated grasses.

(b) Improvements in rotational grazing and

(c) Exploration of new fodder crops, in addition to improving the existing ones.

BY

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INTRODUCTION.

In a country like India where the progress of agriculture depends to a large extent on the efficiency of the work cattle and where there is an increasing demand of milk for the growing population, an adequate fodder supply is a prime necessity. In meeting fodder requirements of the cattle population, it is necessary to visualise two different aspects of the problem.

(a) factors affecting the urban areas where the cattle are reared for milk production, and

(b) those affecting the rural areas where they are maintained chiefly for agricultural purposes.

In the urban areas, where the animals are generally stall-fed on cultivated fodder crops, together with available quantity of concentrates (and therefore, better in health than their counter-parts in the rural areas), the problem is one of economics than of insufficiency of fodder supply. The condition of the working cattle in the rural areas is extremely unsatisfactory. Apart from a few fortunate individuals, who can afford to cultivate fodder crops exclusively for stall-feeding their animals, an average cultivator, with his meagre holding, does not find it possible to grow sufficient fodder. He leaves his stock to derive its nutrition

entirely on natural grasses as are available from the adjacent grazing areas, supplemented to a negligible extent by the crop residues. These grazing areas are often poor both in quality and the quantity of the forage produced. The malnutrition of the work cattle adversely affects the agricultural efficiency and general food production. In view of the above facts, the fodder problem can be resolved into :—

(A) *Urban areas.*—Where cheaper and greater fodder production per unit area is desired so as to enable the dairy owners to sell the milk or milk products to the consumer at a cheap rate. This can be effected by the cultivation of perennial grasses which afford a cheaper fodder, introduction of new high yielding fodder crops and the improvement of the existing ones by manurial and other cultural treatments.

(B) *Rural Areas.*—Where there is a need to increase the productivity of the natural grass-lands which constitute the main resources of fodder supply. This can be achieved by the introduction of improved grazing practices such as rotational grazing, introduction of better indigenous grasses and legumes, reseeding and other methods.

2. The study of fodder and forage crops received attention at the Agricultural Research Institute soon after its establishment at Pusa in 1905. The study, however, in the early years was necessitated by the problems of proper feeding of the experimental Dairy herd and the work cattle. An evenly distributed supply of both bulk and protein rich green fodder throughout the year was recognised as an important aspect in the economic management of the dairy. The studies were, therefore, directed to develop a suitable system of cropping which would ensure such a steady supply. In the cropping system thus developed, *i.e.*, maize-berseem rotation, there existed two periods, when the supply was at its minimum. These two gaps were (i) October-November, the period between the harvest of maize and the first cut of berseem, and (ii) May-June-July, the period between the last cut of berseem and the first cut of maize. The scarcity of sufficient quantity of green fodder during these two periods naturally resulted in reduced milk yield and was a strain on the health of the work cattle. This difficulty of meeting the green fodder requirements of the dairy herd is generally felt wherever periodical droughts exist, experiments were therefore, conducted to evolve suitable fodder crops which could produce sufficient fodder during the gap periods. Work was also undertaken to find out economic utility and relative importance of the cultivated and indigenous fodder grasses and legumes which could be utilised to increase the fodder production.

3. While this work of practical nature has been in progress at I.A.R.I., as well as in other parts of the country, investigations on the fundamental aspects of the fodder and forage crops had so far received very little consideration. The agricultural utility of our native forage species, which constitutes a fundamental study, still remains to be explored. Structure building quality of grasses in association with suitable legumes, conclusively proved at Aberystwyth and elsewhere, can be harnessed to maintain and improve the soil fertility on the cultivated fields as is being done in the advanced countries of the West, where the grass-legume ley forms a pivot crop on which all other crops are rotated systematically all over the field. The problem of maintaining the soil fertility in India is as acute as its fodder problem and intensive research is necessary to find out suitable grass and legume mixtures serving a dual function of maximum fodder production for the underfed cattle as well as maintenance and improvement in soil fertility. The soil binding capacity of the grasses is yet another valuable character which can be utilized in checking the effective run-off or erosion—a problem which is confronting the agriculturists all over the world.

4. The need of an organised research on these lines was emphasized by the present Director of the I.A.R.I. in drawing up the Development Schemes for the Institute in 1945, and an Agrostological Section was established with nucleus staff in 1947.

5. The proposed programme of work of Section includes both the Agronomic and the Botanical aspects as given below :—

Agronomic.

(A) (1) Collection of seeds of the known cultivated fodder crops.
(2) Yield trials with the local ones.
(3) Multiplication of the selected varieties for adoption in the cropping system.

(B) (1) Collection of seeds of natural grasses and legumes, indigenous and exotic and their establishment in the nursery.

(2) General palatability and growth studies and selection of promising species for grazing, cultivation and anti-erosion purposes.

(3) Collection of seeds of selected species for multiplication and detailed trials.

(4) The selected species will be subjected to the following tests :—

(a) Chemical analysis at different stages for their nutritional value.
(b) Detailed growth studies.
(c) Yield trials under irrigated and non-irrigated conditions.
(d) Mowing trials to study the effect of periodical cuttings on the yield.
(e) Hay and silage quality.
(f) Manurial and cultural treatments.
(g) Grazing studies.

(5) Multiplication of the more valuable species and their strain investigations.

(6) Seed mixtures for yield and effect on soil fertility as judged by the subsequent yields with cash crops.

(C) *Botanical work.*

(1) Identification and preparation of grass herbarium
(2) Botanical Survey of grass lands.
(3) Study of succession in grass lands.
(4) Breeding of superior strains.

A. *Selection and propagation of perennial cultivated grasses.*

6. The potentialities of grasses as affording a cheap, perennial supply of high bulk of palatable green feed, attracted early attention and trials were undertaken at Pusa to establish some of the outstanding exotic grasses. Seeds of number of valuable exotic grasses were collected from different sources and as many as 20 grass species were established and kept under observation for a number of years. Out of these Napier (Pennesetum purpureum), Rhodes (Chloris gayana), Guinea (Panicum maximum), and Sudan (Andropogon-Sudanesis) were found promising and on the basis of palatability and their high yielding capacity, were selected for further propagation.

7. The trials conducted at New Delhi confirmed the usefulness of Napier and Rhodes and these have since been established in the permanent irrigated grass plots. Napier, although giving a very high bulk of about 800 maunds of green fodder in 5 to 6 cuttings, is rather coarse and more suited to the work cattle. The Rhodes grass has proved a valuable addition to our fodder crops. It gives quite a high bulk of about 500 maunds of very palatable forage in 5 to 6 cuttings and is available to the milch cattle during November and again in March, April and June when other fodders are not available. The manurial requirements of this important grass have been under study during the past three years. A mixture of sulphate of ammonia (80 lbs. N) and superphosphate (80 lbs. P205) yielded 340 maunds per acre against the control which gave 215 maunds.

8. Guinea grass, like the Napier, was relished by the work cattle alone, but gave a much lower out-turn than the latter and remained stunted during winter. Sudan grass, on early maturing annual resembling Jowar plant, gave promising yields and has recently been multiplied for further trials. It gives 200—250 maunds per cut.

9. The results of these experiments here and elsewhere in India point to the need of experimenting on a large number of exotic grasses and as Dr. Burns puts it 'one hit in 50 years would justify such experimentation (1) Since soils and climatic conditions are so varied in India a particular grass may not suit one locality but may prove superior under certain other conditions. Thus, Paspalum dilatatum or Golden Crown grass which was first introduced in India as an extremely drought resistant one, has not proved very satisfactory in the plains but does very well in the hill tracts of Assam. It is therefore necessary to try these grasses under a variety of soils and climatic conditions before their suitability for introduction can be judged.

10. The exotic grass species under observation in the I.A.R.I. are Star grass (Cynodon plectostachyum), Para (Brachiaria mutica), Venezuela (Melinis minutiflora), Golden Crown (Paspalum dilatatum), and species of Bromus (Prairie grass), Phalaris, Locium (Rye grass), Agropyrom (Wheat grass), Magrostis (Love grass). Some of these appear to be promising as winter grasses. Efforts are being made to obtain seeds of grasses from China, U.S.A. & Australia and other countries to see if any of these will flourish under our conditions.

11. While some of the exotic grasses may still prove to be useful as perennial fodder crops, it is the indigenous grasses that deserve better attention than have been hitherto given to them. Considerable work has already been done on the chemical composition, particularly the mineral contents of the Indian grasses. The investigations of Lander in Punjab (2) Ramiah in Madras, K. C. Sen in U.P. and others show that some of these grasses are fairly rich in nutritive value. The agricultural aspects have so far received very little attention. The early trials conducted at various places in Bombay Province (3), C.P. (4), and more recently at Coimbatore, Izatnagar (5) and at Sirsa on the more common grasses indicate that some of these such as Dichanthium annulatum (Marvel), Schima nervosum (Paonia), Cenchrus ciliaris, Cenchrus Setigerus (Anjan, or Kolukatti), Heteropogen contortus (Surwala), can very profitably be brought under cultivation. These grasses are very adoptable and occur under a variety of soil and climatic conditions. There are still other grasses which may be superior either as pasture or cultivated grasses or as anti-erosion plant cover.

12. The nature of more recent work on the manurial and other aspects of the grasses has been briefly summarised by Dr. K. C. Sen (6), "The results of Nagpur experiments have indicated that the different types of fertilization of the grass plots, fairly rich in essential soil constituents, do not materially improve the quality of the grass, but the total yield is markedly increased. In Sabour and

Coimbatore, where the soils are poor in nitrogen, the application of nitrogenous fertilizers has not only increased the total yield but also the quality of some fodders and grasses as could be observed from the significant increase in protein content in these plants. Similar results have also been recorded in the manurial experiments conducted at Dacca and Kanpur. The study of the yield and the composition of fodders and pasture grasses cut or grazed at frequent intervals is of considerable importance. Investigations of this nature have been carried out at Lyallpur, Nagpur and Jhansi and the results so far obtained have confirmed the observations of the British workers that the frequent cutting or grazing has the effect of lengthening the most nutritious period of the life of the herbage''.

13. With a view to study the agricultural utility of the indigenous grasses, a large collection of both perennial and annual grasses from various parts of the country, was started at the I.A.R.I. since 1941. The grass nursery thus established exhibits about 40 different perennial species with some of their available strains commonly met with in our grass-lands. The following species have been selected for detailed field trials :—

1. Heteropogon contortus.
2. Chrysopogon montanus.
3. Pennesetum orientale.
4. Themeda anathera.
5. Dichanthium annulatum
6. Sehima nervosum.
7. Bothriochloa pertusa
8. Cenchrus ciliaris.
9. Cenchurus setigerus.
10. Panicum repens.
11. Arundinella nepalensis
12. Setaria palmaefolia.
13. Themeda tremula and
14. Panicum antidotale.

Observations are being taken on others for further selection.

B. *Improvement in Rotational Grazing.*

14. In the economic utilisation of the grass lands for grazing purposes, management plays a very vital role. To state in the words of Sir R. G. Stapleton who stressed this point in his opening address to the Fourth International Grassland Congress at Aberystwyth in 1937. " Soil, climate, grazing animal. Which of these three is the most important factor ? Most emphatically the grazing animal.

15. Manure right, sow right and manage the grazing animal wrong and you are nowhere. Without the grazing animal there would be no grassland worth the name anywhere in the world. Management is, therefore, the key to the solution of the whole grassland problem ".

16. The present deterioration of grassland is primarily due to the unsystematic grazing practices of our uninformed graziers. It is a common practice of the village graziers to allow any number of animals in the village grazing areas, as soon as it becomes green after the out-break of monsoon. Such a practice arises

out of the need of the villagers to restore the condition of their animals in as short a period as possible. The grasses in younger stages are very nutritious and the animal pick up condition very speedily when grazed at this stage. The grazier, however, is unaware of the damage done to the vegetation. This, too early, continuous, and overgrazing, in association with the selective grazing habit of the grazing stock, practiced year after year, results in the depletion of the vegetation and consequently affects the carrying capacity of the pasture. Since grazing is inevitable what is needed, therefore, is the introduction of an improved system of grazing which will afford the maximum utilisation of the forage, with least interference with the seed formation of the forage species, together with the maximum gains to the grazing stock.

17. The deferred and rotational system of grazing as developed in U.S.A., and now practiced on ranges and cultivated pastures in many countries takes into consideration all the above factors and can be successfully applied to our grasslands, particularly, where annual species predominate. This system is applied by dividing the pasture in a number of compartments depending upon the size of the pasture, each being grazed in rotation in the early part of the grazing season and protected subsequently, so that once during the cycle (depending upon the number of compartments) each compartment is allowed to autoseed itself with part season protection for the successful establishment of the young seedlings, in the succeeding years. By applying this system it is possible to maintain a larger number of animals in a unit area than it would be under the continuous system of grazing. Thus in an experimnet to see the effect of different intensities of grazing on the local vegetation and the grazing stock, carried out at Mandane, N. Dakota in U.S.A., by Sarvis (7), 15 animals could be grazed under deferred and rotational grazing system in 70 acres pasture divided into three compartments, with approximately the same gains in live weight as the 10 animals grazing under continuous system on a pasture, similar in size and forage production.

18. Before this system of grazing, as developed in U.S.A. in toto or with such modifications suitable to Indian conditions, can be recommended for wider application, it is absolutely necessary to have a sufficient data with regard to the types of grasslands met with in the country, the nature and relative abundance of the forage species entering into their composition, carrying capacity, behaviour of the vegetation under different systems of grazing. It will also be useful to ascertain the reaction of the villagers to the introduction of rotational grazing which is a deviation from their normal practices.

19. The first systematic attempt in India to collect data on rotational grazing was made by Burns, Kulkarni and Godbole(8) at Bhamburda near Poona in 1928. The results of their investigations show that the quality and quantity of the forage and consequently the carrying capacity could be increased considerably; the gains in live weight of the grazing animals varied from 17 to 26 per cent. Further experiments carried by Kumar and Godbole(9) at Mangadana near Poona for a period of 7 years showed that the number of grazing animals in the same area could be increased from 150 in 1931 to 250 in 1938, thus confirming the results of the earlier workers.

20. The work has then taken up by the Forest and Agricultural Departments in several provinces. During recent years the problem has received considerable attention and a number of schemes with a view to collecting further data on rotational grazing are being carried out in different Provinces and States. Mention may be made to the I.C.A.R. Pasture Land Improvement Scheme in Baroda State. The results of one of the grazing schemes indicated that in the utilisation of eroded areas for grazing purposes, Intermittent grazing with a fortnightly closure period gave the maximum gains to the cattle, with minimum erosion percentage, when compared to controlled continuous and post monsoon grazing.

21. The work on rotational grazing and other aspects of grassland investigations will be started next year by the Agrostological Section of the Indian Agricultural Research Institute.

C. Exploration of New Fodder Crops in addition to improving the existing ones.

22. The work done and intended to be done on the exploration of new fodder crops has been described in another note submitted to the Board by Pal and Singh. It is, therefore, proposed to limit the scope of this note to the work on improvement of the existing crops.

23. The main fodder crops which are cultivated in one or the other parts of the country are the following :—

Kharif.—Jowar (Sorghum vulgare, *maize* (Zea mays), *Bulgara* (Pennesetum typhoidium), *ragi* or *Nachani* (Eleusine coracana), *cowpeas* (Vigna catjang), *guar* (Cyamopsis psoralioides), *meth* (Phaseolus aconitifolius), *velvet bean* (Stizolobium deeringianum), *soybean* (Glycine hispida), *val* (Dolichos lablab).

Rabi.—Oats (Avena sativa), *berseem* (Trifolium alexandrinum), *shaftal* (Trifolium resupinatum), *lucerne* (Medicago sativa), *senji* (Melilotus parviflora and M. alba), *methora* (Trigonella foenumgroecum), *Japan rape* (Brassica napus) and *turnips* (Brassica rapa).

24. As a result of several experiments conducted both at Pusa and New Delhi, to find out the relative merits of the different fodder crops, it is now possible to have green fodder practically the whole year round as shown below :—

August ..	.. Jowar and guar.	November	.. Cowpeas.
September	.. Jowar and Cowpeas.	December to May	Berseem.
October ..	.. Jowar and cowpeas.	June : July	.. Cowpeas and maize.

25. The work on the improvement of these and other crops, by breeding superior varieties and by cultural, manurial and other treatments has been in progress at I.A.R.I. and elsewhere in India. Some of this work is briefly summarised below :—

26. *Jowar.*—(Sorghum vulgare) provides an excellent fodder both for soiling and silage purposes. Its sowing can be adjusted so as to yield green fodder from early May to end of August. Suitable varieties exist which could be sown in February and would be ready for cutting in 60 to 70 days under irrigated conditions. The main season crop is sown with the break of monsoon and U.P. Purbi has proved superior to others at Delhi. This has now been adopted in general cultivation here.

27. Considerable amount of work has been done, particularly, in Punjab and Sind on fodder varieties of Jowar. Amongst these, may be mentioned Honey Sorghum, *Kamadari, Red Turi.* These are high yielding varieties but differ from others in that they are shy seeders. It will be worth while to devote attention to this problem.

28. The manurial experiment at New Delhi, showed that significant increase could be obtained by nitrogenous manures, like nitrate of ammonia and sulphate of ammonia at a rate of 40 lbs. nitrogen per acre. Treated plots gave a yield of 902 maunds per acre against the control which gave 851 maunds per acre.

29. *Maize.*—(Zea mays) PF1, PF2 and PF3 Pusa selections were found to be successful, PF2 being the best yielder giving about 200 mds., per acre of green fodder. Experiments have shown that maize when grown after phosphate manured berseem field gave a significant response.

30. To maintain the purity of the desirable type under cultivation, it is necessary to resort to mass selection every few years as the crop is cross-fertilized.

31. *Cowpeas* (Vigna catiang).—The study of cowpeas was carried out at Karnal Sub-station as part of Empire Co-operative studies on behalf of the Royal Botanical Garden, Kew. About 2,000 samples were collected from various parts of the world. Of these 200 distinct types were isolated. Out of these K397, K700, K585 and K782 proved superior under Delhi conditions. K397 and K700 have been adopted in the general cropping system. Cowpeas is now the principle source of protein rich fodder during June, July and from September to November either alone or when grown in mixture with maize. Investigation regarding the manurial requirements showed that cowpeas do not respond to phosphatic manurials as was the case in other leguminous fodders. The manuring, however improved the quality of cowpeas. The P2O5 content of the fodder rose from 0.32 to 0.43 per cent. and calcium from 2.86 to 3.41 per cent.

32. *Soyabean.* (Glycine hispida).—This is a newly introduced fodder crop and was found very valuable particularly at Pusa as it supplied green fodder during the month of November when no other green feed was available. It yielded about 150 maunds per acre. As a result of trials conducted on yellow, chocolate black varieties of this crop, chocolate was found to be superior. At Delhi, however, cowpeas which is a better yielder has replaced this crop. Further selections from imported 24 American varieties of soybean are on hand.

33. *Berseem* (Trifolium alexandrinum).—Since the introduction of this valuable clover as a *rabi* crop in 1917 at Pusa, its importance as the soul source of protein rich green fodder throughout winter and again in summer till May, has remained unquestioned. It is now grown all over India. Several alternative *rabi* fodder crops like *methra, senji, field peas,* and *Khesari*, were tested for their yields but none stood any comparison with berseem which gave much increased yields in regular monthly cuttings from December to May.

34. The extension of this crop in early years was limited due to the scanty seed setting habit in India. Seed had to be imported from Egypt. It has now been possible to obtain good amount of seed by suitable cultural and manurial treatments. Experiments conducted at New Delhi and elsewhere have shown that the maximum quantity of good seed, is obtained after the third cut—a practice now being followed at I.A.R.I.

35. Results of the experiments with regard to the best sowing time and manurial and irrigational requirements, proved that sowing in the middle of October, manuring it with higher dose of superphosphate upto 120 lbs. P2O5, either alone or in combination with F.Y.M., combined with regular irrigation at an interval of 12 days, maximum yields could be obtained. The average yields of the general crop on the farm, varies from 300 to 350 mds., per acre, the maximum yields were about 600 maunds per acre.

36. The experiments on phosphatic manuring of berseem and other leguminous croup brought about a striking fact that all legumes do not respond to phosphatic manures equally. Berseem showed a positive respones to the phosphatic manures not only in the yields but also in the P2O5 and CaO content of the fodder. The P2O5 and CaO contents were respectively raised from .38 and 3.206 per cent. of the control to 1.12 and 4.14 per cent. in the plots manured with higher doses of superphosphate at the rate of 264 lbs. P2O5. Based upon

these findings at Delhi, a request was made to the different Provinces with a view to obtaining these results under varying soil and climatic conditions. The manuring dose may appear very heavy but it has great residual value over succeeding crop. Isolation of strains and the testing of these against the local variety are in progress.

37. *Lucerne* (Medicago sativa).—This valuable perennial clover forms a source of additional protein rich green fodder during *rabi* season. Milch cattle do not seem to relish it much but the work bullock consumed it readily. Experiments undertaken to study its cultural and manurial requirements showed that maximum yields could be obtained by broadcasting the seed and the application of higher dose of superphosphate (120 lbs. P2O5). The average yields per acre varied from 300 to 330 maunds.

38. *Conclusion.*—The fodder problem is a serious one in India. Our cattle wealth will deteriorate if the feeding is not sufficient or efficient. The present position is far from satisfactory. There is urgent need for improving our fodder resources by all available means and the introduction of suitable grasses and improvement of grasslands and pastures provide an effective method of achieving this end. The Departments of Agriculture in Provinces and States should have Agrostological section and work on this problem should be intensified.

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SEVENTH MEETING OF THE CROPS AND SOILS WING OF THE BOARD OF AGRICULTURE AND ANIMAL HUSBANDRY IN INDIA, 1948.

SUBJECT No. 6A.—*Selection propagation of perennial cultivated grasses.*

Note by

N. C. Das Gupta, Research Officer, Cattle Feeding Research Scheme,

United Provinces, Bharari, Jhansi.

Legume roughages are the richest source of protein as compared to common roughages like straw, karbi common grass and grass hay.

Home grown legume fodders supply protein of food quality to livestock most economically. A rough estimate of the extent of inadequacy of the nutrients for the livestock of India shows that the available digestible protein is about one-seventh of the required quality. Hence, the importance of legume fodders cannot be ignored. Western countries depend mostly upon pasture with legumes for their cattle. But a perennial legume to suit the ecological condition of India has not yet been found, except lucerne which is suitable only to a certain extent. It is high time that a search is made for other perennial legumes which can be easily established in India.

Arhar or pigeon pea (Cajanus Indicus or Cajanus Cajan) a perennial legume of tropical and sub-tropical countries is an important human food crop in India. Though it has been tried in some tropical countries as cattle fodder, here in India only the straw is used for this purpose. In Hawaii[1], pigeon pea has been found to make excellent pasture and the young growth is also used as a soiling crop. Cajanus Indicus has been mentioned as a forage crop by Navarrete[2]. It has also been tried as a fodder grass in Barbados[3]. Pigeon pea (Cajanus Cajan) was selected for study as a perennial tropical legume by Schofield[4] and was found to be a valuable stock food. Henke[5] has recorded that much lower amounts of protein concentrate are necessary in the diet when cajanus Cajan is fed as a soiling or pasture crop.

Different varieties of *Kudzu* (pueraria thunbergiane, pueraria hirsuta and pueraria phaseoloides) a perennial legume, have been found to be quite satisfactory as cattle feed.

Pueraria thunbergiana has been found to be the most prominent legume for fodder and grazing. It is being studied in grazing grounds on hill slopes around Poona[6]. Throughout the south-eastern United States it has been extensively planted on the eroded soil. A well established crop of Southern Piedmonth Experimental station produces five tons air dry hay per acre[7]. The mature hay was found to contain 3.18 per cent. nitrogen. Some work with pueraria hirsuta was also conducted in India.

Tropical species of *Kudzu* have been reported from the Phillipine, New Guinea and China. They grow in the jungle, thrive beneath trees inspite of the competition of the latter for water, and grow in grass lands where vines keep down on the ground surface. A tropical *Kudzu*, identical as pueraria phaseoloides

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but not identical to that available in the Phillipine, has been grown in Puerte Rico since 1940. These tropical species have been recommended for Carribean area and Pueraria thunbergiana fails to grow satisfactorily. For the same reason Pueraria phaseoloides was introduced in Puerto Rico.

In India where excepting lucerne no perennial legume has yet been established, it is desirable that systematic studies are made with the different species of *arhar* and *Kudzu* along with lucerne to select strains suitable for different parts of the country for providing green fodders for the maximum period of the year and also for the maximum return of nutrients per acre. It may be mentioned that there are possibilities of growing Kudzu on land not fit for food production.

Plan for studying *arhar* and *Kudzu* as a fodder crop is already under consideration of the Department of Animal Husbandry, United Provinces.

SUBJECT No. 6(*B*).—*Improvements in rotational grazing.*

Note by.—K. Cherian Jacob, L.Ag., F.L.S., Coimbatore.

At a meeting of the Madras Provincial Fodder and Grazing held on 17th January, 1947, I explained that if Forest Fodder Grasses were first cut just at the time of flowering in the month of October, a second cutting could easily be made in the following January, which would thus give two harvests resulting in the total output of fodder by 100 per cent.

Forest officers present at the meeting explained that it was doubtful whether the forest grasses would regenerate after the first harvest in the forest grazing areas under the existing conditions.

I explained that I have been getting two and often three harvests of grasses at Coimbatore, typical of scanty rainfall area, with all species of important forest fodder grasses.

These forest grasses are grown at Coimbatore year after year without any attention being bestowed on them except for occasional weeding but with one difference *viz.* the plots have all the four sides raised to form bunds of about 6 inches height. These bunds prevent runnings off of any rain received in these grass plots ; whereas in the forest grazing areas most of the rain water received runs off, the land being generally slopy.

If moisture can be conserved, the output of forest fodder grasses could easily be doubled if not trebled.

Any amount of money spent on the conservation of moisture is an investment. The cost of sinking wells can be reduced very much since water table rises in such areas and the irrigation water need only be lifted to much less extent. When the moisture content of the soil is increased, there also be difference in the species of grasses present. The contour trenching and bunding gives a partial effect of digging of the place ; consequently the land is improved.

The so-called hardy grass species like *Andropogon montanus*, *Eragrostis bifaria*, many species of *Aristide*, *Andropogon Controtus*, etc., which are of xerophytic nature give place to *Andropogon Pertusus* (*Amphilophis pertusa, Pothriochloa Pertusa*), *Iscilimea laxum Andropogon pumilus*, *Pennisetum cenchroides* and other non-xrophytic grasses of much higher fodder value.

I suggest therefore that the conservation of moisture and wherever necessary conservation also of soil may be systematically done by Contour trenching and contour bunding, as found necessary, as is successfully done in the Bijapur and other districts of the Bombay Province so that the output of fodder of superior fodder value may be doubled or trebled in areas of scanty rainfall.

SUBJECT No. 6(C).—*To review the measures adopted to increase the fodder production by* :—

(c) Exploration of new fodder crops in addition to improving the existing ones.

Note by

Sardar Bahadur Sardar Harchand Singh, Commissioner for Agriculture, Patiala.

Of course the exploration of better fodder crops is a necessity and there is no limit to what we should aim to secure but the more important quarter of this problem is the introduction of some fodder crops whose superiority is well established but which are not being grown either due to ignorance, non-availability of seed or the lack of technique in the methods of its cultivation. Take the specific case of Berseem. This has established its superiority over the fodder crops which it had replaced. Two difficulties are being felt about this crop.

No. 1. Unless the seed is inoculated it shows very poor results in new soils where it has never grown before. Experience has shown that by inoculating the seed, yield increases by four times. Arrangements should be made for inoculating the material which can be prepared only under the direction of Agricultural bacteriologist. Arrangements should be made for supply of this seed.

2. The seed is selling at very high rates and in fact is not available in sufficient quantity to meet the demand of the market. This difficulty has considerably increased as the result of the partition of the country. Some special efforts should be made for the production of seed at the farms or through the Private Growers.

Napier Grass.—It was introduced at the Bhupendra Dairy Farm, Patiala in the year 1936, for the object of providing some green stuff to the cattle at the hottest season when rarely any thing green can be looked any where. It has been grown continuously for the last eleven years. It needs heavy manuring every year and consequently it was planted quite at the head of a liquid, manure pits round about which irrigation of liquid manure can be easily made.

The object of locating it round the pit was also to consume the liquid manure easily which it does to any extent. It needs deep interculture with a plough and there is no danger of any kind of any injury to it, once it is well established. After that it gives very good foliage year after year with proper manuring and interculture every season for 10 years, after which period it ought to be removed to another area, because the land gets much infested with pests and insects.

Being a wild grass of African tropical parentage it thrives best from March to October and during winter months of November, December. January and February, its growth is dorment, in Patiala climate.

On the average 250 mds. of green fodder per cutting per acre is available from this grass. Ten cuttings a year should be taken which means an yield of 2,500 mds. roughly 100 tons per acre per year. Tonnage depends upon the growth, when it is cut and the number of cuttings taken. Bigger the growth, greater the yield per cutting but lesser shall be the number of cuttings. Thus the yield annual per acre may remain the same.

As a cattle fodder it may be considered as a supplementary and economy measure. To that extent which adds to the weight of green fodder, it saves the use of more expensive crops like Maize, Chari and other cereals which give only one cutting, while it can not in any way stand as nutritious as cereals. It is chaffed along with green cereal crops and fed to the cattle. If you entirely depend upon elephant grass for your green fodder ration, it is not relished by cattle.

They lose in health. Therefore, it should only be used as supplement to green fodder. Ordinarily Zamindars can not be advised to put it on their land unless they are well provided with surplus water and manure and take up fixed farming. Its introduction merely as a fodder for bullocks is inadvisable on account of its low nutritive value.

SUBJECT No. 6(C).—*Exploration of new fodder crops in addition to improving the existing ones.*

(Note by B. P. Pal and Harbhajan Singh, Division of Botany, Indian Agricultural Research Institute, New Delhi.)

In agriculturally-advanced countries fodder crops are considered just as important as any of the food crops of other industrial crops. Recent researches on grasses and legumes and grassland farming in general have shown how these can contribute materially to the prosperity of a country. In India with the increasing demand in land for the growing of food grains, and the increasing need for draught cattle and for pure milk and milk products it becomes imperative that serious attention is paid to the improvement of existing fodders and the exploration of new fodders which may be found useful substitutes for the existing ones or which may turn out to be promising fodders for new agricultural areas where other fodder plants might have failed. It becomes all the more important when we consider that over a greater part of our country rainfall is concentrated in a few months of the year and in the hot weather the temperature in most places is hardly conducive to vigorous growth of the various fodder and forage plants. Except for a few of the rainy season crops fodder generally are grown under irrigated conditions. But irrigation facilities are not available over a large area in the country. Hence there is urgent necessity of developing pastures with suitable grasses and legumes either separately or in mixtures which would give good pasture growth under low rainfall conditions and which would at the same time enrich the soil. All available waste cultivable land in the country can profitably be utilized for the development of temporary or permanent leys with suitable grasses and legumes. These areas can be later utilized for growing other crops also.

In India no systematic attempts have so far been made to explore the possibilities of introducing new fodder crops either by introduction from other countries or through explorations within the country. A small scheme for the introduction of new economic plants financed by the Indian Council of Agricultural Research has started working at the Indian Agricultural Research Institute, New Delhi. A beginning has been made in the collection of useful indigenous and exotic plant material including fodder and forage crops. If and when a full-fledged Bureau of Plant Introduction which is under the consideration of the Government of India is instituted, it will be possible to undertake, on a more extensive scale, the collection, study and maintenance of new plant material. In the study and maintenance of the material so far collected the Divisions of Botany and Agronomy are Co-operating, the former dealing in particular with the introduction, description and hybridization aspect and the latter with its utilization for fodder, forage and pasture purposes.

I. *Fodder and forage plants generally cultivated in different countries.*

Before discussing the question of new fodders for the country it would be worthwhile examining the range of plant material that is available for trial. There are two main types of fodder and forage plants *viz.* those grown as field crops and those grown for pastures and grasslands. The bulk of the commercial fodders belong to either the Leguminosae (legumes) of the Gramineae (grasses).

The leguminous plants. The various fodder yielding legumes, cultivated in different countries either as field crops or for building up pastures and grasslands, are given below :—

Common English Name.	*Vernacular Name.*	*Botanical Name.*
Egyptian Clover, Berseem	*Berseem*	*Trifolium alexandrinum.*
Persian clover	*Shoftal*	*T. resupinatum.*
Alsiki clover	..	*T. hybridum.*
Redclover	..	*T. pratense.*
White lclover	..	*T. repens.*
Crimson clover	..	*T. incarnatum.*
Yellow suckling clover	..	*T. dubium.*
Subrorranean clover	..	*T. subterraneum.*
Strawberry clover	..	*T. fragiferum.*
Lucerne, alfalfa	*Lucerne*	*Medicago sativa.*
Yellow alfalfa	..	*Medicago lupulina.*
Yellow alfalfa	..	*Medicago falcata.*
Yellow Melilot	*senji*	*Melilotus Indica—M. perviflora.*
White malitot	*senji*	*M. alba.*
Fenugreek	*methra, metha*	*Trigonella foenumgraecum.*
Sainfoin	..	*onobrvchis sativa.*
Common Birdsfort trefoil	..	*Lotus corniculatus.*
Greater Birdsfoot trefoil	..	*L. major.*
	..	*Lotus hispidus.*
	..	*L. angustifolius.*
Kidney Vetch	..	*Anthyllis vulneria.*
Vetch	*akta*	*Vicia sativa.*
Vetch	..	*V. Villosa.*
Indian Vetch	*khesari*	*Lathyrus sativus.*
Cowpea	*lobia*	*Vigna ungiculata—V. catjang.*
Soybean	*soyabean*	*Glycine max.*
Fieldpea	*Matri, kerao*	*Pisum arvense.*
Gluster Bean	*guar*	*Cyamposis psoralioides.*
Moth Bean	*moth*	*Phaseolus aconitifolius.*
Green Gram	*mung*	*P. aureus.*
	meth	*P. trilobus.*
Blue lupin	..	*Lupinus angustifolius.*
Yellow lupin	..	*L. luteus.*
Tropical kudzu	..	*Pueraria phascoloides.*
Japanese kudzu	..	*P. hirsuta—P. thunberigiana.*
Perennial Lespedeza	..	*Lespedeza sericea.*
Annual Lespedeza	..	*L. striata.*
Wild lucerne	..	*Stylosanthes sundaica.*
Wild lucerne	..	*S. guyannensis.*
Sann-hemp	*Sanai*	*Crotelaria juncea.*
Broad Bean	*Bakla*	*Faba. vulgaris.*
Horse gram	*kulthi*	*Dolichos biflorus.*

Some of the above-mentioned plants *viz. berseem, alfalfa, senji, metha, cowpea, guar, are* classed as good fodders and are in general cultivation as field crops in different parts of India. Others like *shaftal Kerao, moth, kulthi. Khesari* are also cultivated though on a small scale only. Sann-hemp is sometimes fed to cattle in the early stages of growth when no other fodder is available.

The grasses.—The following is the list of the members of the grass family which are cultivated as cattle feed in one form or another in various countries :—

English Name.	*Vernacular Name.*	*Botanical Name.*
Sorghum	*juar, cholam*	*Sorghum vulgare.*
Sudan grass	*Sudanghas*	*S. sudanensc.*
Johnson grass	*baru*	*S. halepense.*
Rhodes grass	*rhodes grass*	*Chloris gavana.*
Napier	*hathighas*	*Pennisetu purpureum.*
Kaikuyu		*P. clandestinum.*

Common English Name.	*Vernacular Name.*	*Botanical Name*
Bulrush millet	*bajra, bajri*	*P. typhoides.*
Oats	*jai*	*Avena sativa.*
Oats	*jai*	*A. sterilis.*
Barley	*jau*	*Hordeum vulgare.*
Maize	*Makai*	*Zea mays.*
Para grass	..	*Panicum baribonode.*
	Sanwak	*P. colonum.*
Guinea grass	*guinea ghas*	*P. maximum.*
Perennial rye	..	*Lolium perennoe*
Italian rye	..	*L. italicum.*
Smooth Brome grass	..	*Bromus inermis.*
....	..	*B. catharticus.*
Rescue grass	..	*B. unioloides.*
Cocksfoot	..	*Dactylis golmerata.*
Dallis grass	..	*Paspalum dilatatum.*
Upright Paspalum	..	*P. Virgatum.*
Timothy	..	*Phleum pratense.*
Kentucky Blue grass	..	*Poa pratensis.*
Bird grass	..	*P. trivialis.*
Canada Blue grass	..	*P. compressa.*
Red Top	..	*Agrostis.*
Canry grass	..	*Phalaris canariensis.*
Trowoomba canary grass	..	*P. tuberosa.*
Bannry grass	..	*P. bulbosa.*
Reed canary grass	..	*P. arundinacea.*
Canary grass	..	*P. stenoptera.*
....	..	*Festuca gigantec.*
....	..	*Brachypodium phoenicoides.*
Teff	..	*Eragrostis abyssinica.*
African Love grass	..	*E. Curvula.*
Lehman Love grasss	..	*E. lehmani.*
Molasses grass	..	*Melinis minutiflora.*
Carpet grass	..	*Axonopus compressus.*
Sweet vernol grass	..	*Anthoxanthum odoatum.*
Slender wheat grass	..	*Agropyron tenerum.*
Crested wheat grass	..	*A. cristatum.*
Couch grass	..	*A. elongatum.*
Intermediate wheat grass	..	*A. intermedium.*
Wild rye grass	..	*Elymus junceus.*
Teosinte	..	*Euchlaena mexicana.*
Giant star grass	..	*Cynodon plectostachyum.*
Bermuda grass	*dub ghas*	*C. dactylon.*
Natal grass	..	*Tricholaena rosea.*
Italian Millelt grass	*Kangni*	*Setaria italica.*
Perennial Veldt	..	*Ehrharta calveina.*
Meadow Fox	..	*Alopecurus pratensis.*
Tall oat grass	*anjan*	*Arrhenetherum elatius.*
....	*anjan*	*Canchrus setigarus.*
....	*apang*	*C. ciliaris.*
		Dicanthium annulatum.

In India the more important fodder grasses grown as field crops are *juar*, maize, oats and barley. Some of the exotic grasses introduced in recent years, *viz.* Guinea grass, Rhodes grass, Napier grass, Sudan grass, etc., have shown promise of becoming commercial fodders. Most of the grasses included in the above list are grown in various foreign countries for pastures and for grassland farming in general. As the establishment and improvement of pastures and grassland have so far remained neglected in this country few opportunities have arisen for the systematic study of the important grasses mentioned in the list.

In the Division of Agronomy the wide collection of indigenous and exotic grasses is particularly interesting. A reference to this collection has been made in a separate note, prepared by Dr. Mirchandani and Dr. Dabadghao of the Agronomy Division. In the Division of Botany several legumes and grasses

with fodder potentialities are under preliminary observation. These include among grasses species of *Agropyron Aegilops, Bromus* (Brome grasses), *Phalaris, Lolium, Eragrostis* (Love grasses), *Molimus* (*M. minutiflora* the grass which is said to keep away ticks from the cattle fed on it), *Paspalum, Pennisatum, Cynodon.* Some of the useful Himalayan fodder grasses *viz. Pennisatum oriental, Apluda aristata, Chrysopogon grylus, Bromus unioloides* and others are in the process of acclimatization. Among the legumes study of the much-talked of *Lesvodeza (L. sericoa and L. Striata)* and kudzu (Tropical kudzu, *Pueraria phaseoloids* and Japanese kudzu, P. *hirsuta*) as also the lupins (blue and yellow) has been taken up along with others. A number of wild species some of them closely related to the commonly cultivated fodder legume partiuclarly those belonging to *Medcago, Trigonolla, Malilotus, Crotalaria, Phaseolus,* etc., are also under observation.

II. *The exploration and introduction of New fodder.*

(1) *Exploration of indigenous plant material.*—Having recognised the urgency of introducing new fodder plants which would be able to grow in areas not ordinarily suitable for growing the more common food crops, attempts should be made to collect and try new fodder yielding species from within and outside the country. Whilst a certain amount of improvement can be affected by the introduction of exotics it is to be expected that the greatest benefit is likely to accrue from the introduction of suitable idigenous material. Thereon obvious advantage with the indigenous species is their easy acclamitization. The wild white clover (*Trifolium ripes*) which is native to Britain is now recognized as one of the important plants available to the farmer in that country. It possesses many valuable attributes lacking in the ordinary or cultivated varieties of white clover. This and the red cover species (*T. pratenso*) grow wild in the Himalayan ranges as well and it may be worth-while experimenting with them. The same can be said of the grasses. We have several of the grasses and legume species mentioned earlier and also many more closely allied to them growing wild which can provide the necessary material to start with. The foreign strain of this species may have some advantages on account of the improvement effected through constant selection and breeding. But it may be possible to evolve still more promising stocks from our own material if proper attention is paid to the problem of strain building. Many of the indigenous grasses have been under trial and whereas several of them have shown high nutritive value the low yield of fodder has been a limiting factor. Yield can however be appreciably increased by further work in the direction of strain building.

(2) *Introduction of foreign types.*—It is possible that some of the introduced foreign strains may establish themselves successfully in the new surroundings. During the past one hundred years or so strains of grasses introduced from Europe by the United States of America have become wildly established. Some of the plants not already tried but which have proved useful elsewhere may be worth experimenting with in this country. In New Zealand the Greater Bird's foot Trefoil (*Lotus major*) has been found useful in the improvement of marshy or peaty and where other legumes did not thrive. Sainfoin, *Onobrychis sativa* grows well under low rainfall conditions. In Hungary there is available a highly alkali-resistant grass *Atropis limosa.* Trial of many of the South African grasses from drought-resistant areas would appear to be advisable.

Some reports on the trials of some of the exotic material mentioned earlier carried out by various agricultural departments and institutions in India are available which show that many of the earlier introductions were discarded as not promising for one reason or the other. One reason for this situation may perhaps be lack of information on the ecological and cultural requirements of the introduced species. Different species may suit different regions so that regional

requirements have got to be worked out in the first instance. Ecological studies can make valuable contributions towards the successful development of pastures and grasslands which are so much needed in our country. In this connection introduction and differentiation of different ecotypes of individual species can go a long way in fitting in new forage plants with new localities thereby extending the range of cultivation of fodder plants. Here again may be emphasized the importance of indigenous material because of natural selection over a long period of time has created much better stabilized eco-types of the species growing wild in different habitatus. The established regional races of *Phloum pratenso* (timothy) in Scotland and *Trifolium pratenso* (Red clover) in England are perhaps the most striking examples of ecotype formation. In the case of Kikuyu grass (*Pennisetum clandestinum*) the well-known African Pasture grass which could not be previously grown outside limited localities in Africa is now extended to large areas as a result of the isolation of three ecotypes. The failure of earlier attempts in the introduction of new fodder plant may be attributed partly to the non-availability of a wild range of ecotypes.

For successful introduction of new plants it is desirable that the material is studied more systematically from different points of view some of which are discussed below :—

(a) Relevant data should be collected regarding the palatability, digestibility, nutritive value, resistance to diseases, drought and cold, tolerance to extreme soil conditions, summer growth, recovery value, seed setting, etc.

(b) *Seed Production.*—Production of viable seeds in appreciable quantities is an important factor in the successful cultivation of forage crops. It may be necessary to find out suitable areas for purposes of seed production. It is often seen that in most cases seed-setting is defective which may be due to various causes. Sterility is one of the chief obstacles to seed production. *Trifolium pratense* (red clover) which is almost completely self-sterile when first introduced into New Zealand failed to set seed owing to the absence of suitable insects and the importation of live humble bees enabled seed crops to be grown. The sterility factor is operating in the case of many of the grasses and legumes. In the case of berseem it has been observed that seed setting is more in areas where pollinating insects are in abundance. Seed setting experiments on berseem carried out at the Division of Botany, Indian Agricultural Research Institute, have established the importance of pollinating bees in bringing about seed-setting in this plant. A significant increase in seed-setting was observed in the case of plants enclosed in cages with bees inside while very little seed was obtained from the plants kept as controls. Hence it is necessary to study the life history of a new plant under the prevailing conditions with particular reference to reproduction.

(c) *Seed inoculation and manuring of legumes.*—It is now an established fact that the true performance of a legume cannot be judged under ordinary conditions of cultivation. The exotic legumes being not native the correct strains of root nodule bacteria are generally lacking with the result that such plants do not grow luxuriantly and also fail to enrich the soil with nitrogen. Again the growth of legumes in general is appreciably increased by the application of phosphatic manures. It may therefore be pointed out that all these legumes which were tried earlier but which were abandoned should be retired keeping these points in view.

(d) *Resort to hybridization.*—The new material may be utilized indirectly for the breeding of improved strains of the existing crops or entirely new crops through hybridization. Crosses between indigenous and exotic varieties or ecotypes as may be more appropriate to call them, may result in really useful plant material.

Interspecific and intergeneric hybridization may also be worth trying out. The perennial wheat produced in Russia as a result of crosses between wheat and couch grass is considered more useful as a hay than as a grain crop. The *Zea-Euchlaena* cross which is easy to make and gives fertile hybrids may yield fodder plant suitable for certain tracts. The tetraploid *Zea-Euchlaena* hybrid produced by Jannaki Ammal at the John Inns Horticultural Institution and named as Merton grass is reported to be a potential fodder. The sugarcane-sorghum and sugarcane maize hybrids produced at Coimbatore deserve further experimentation from the fodder point of view. Similarly the genus Medicago to which belongs the alfalfa, furnishes other related species which if crossed successfully may yield improved fodder varieties of alfalfa. Mention may here be made of *Medicago glutinosa*, a native of Caucasia and *Medicago carsticnsis* a native of Mediterranean region which are very dense and leafy legumes. Another species *Medicago arborea*, the Tree lucerne as it is called on account of its more bushy habit may also be useful in this respect.

The indigenous cane *Saccharum barberi* which can be used as a profitable fodder may yield suitable fodder types if the necessary selection and breeding work is carried out.

III. *Plants other than grasses and legumes.*

In India the fodder yielding plants are mostly legumes and grasses. There is yet another class of fodders—the root fodders which also deserve our attention. The more important root fodders worth trying are mangolds, swedes and turnips. Sunflower has also shown promise of being a good fodder plant under certain conditions. Several improved fodder strains of sunflower have been evolved in foreign countries which could be introduced with advantage. Pumpkins and melons can also be utilized as fodders.

SUBJECT No. 6(C).—*Crops and Soils Wing Meeting, April* 1948.

THE ROLE OF HONEY BEES IN THE SEED PRODUCTION OF FODDER CROPS

BY

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Bee-keeping is well known as a fascinating hobby providing the bee-keeper with one of nature's finest foods. The importance of bees in the production of better fruits and better and larger quantity of seeds is not sufficiently appreciated. Pastor Sprengel, a naturalist at the close of the 18th century first discovered that the insects carried pollen from flower to flower in the same or different plants. The importance of this remarkable observation was not appreciated, till Darwin sixty years later convincingly showed by an array of facts and observations the part played insects in cross pollination. Haydak beautiful describes "bees as high priests of nature that marry one flower to another and for their service they receive a fee in pollen and nectar." In Ohio it was found out by experiments in the field in suitable cages that in the case of alsike clover that in those cages where pollinating insects—in this experiment bees—were excluded the average seed production per head was only 3.4 where as in those cages which were pollinated by bees the average seed production per head was 120 to 125 seeds per head. This experiment brings out prettily clearly the importance of bees in seed production. It may be stated here that in the case of clover the farmer is interested in getting 100 per cent. seed set while in the case of horticular industry—say apple, the farmer

would be more than satisfied in four per cent. of the blossoms on an average bloom set fruit. It was also found out in Ohio that one acre of bloom of alsike clover contained 300,000,000 to 500,000,000 florists. It was found that an abundance of bees in having alone could ensure the pollination of this sea of blossom. It was also calculated that when the seed that set in a head was 50 the seed-yielding capacity of one acre was 5.8 bushels. If it was 90 seeds per head the yield rose to 10.4 bushels while in the case of 120 seeds per head the yield was 13.8 bushels.

Both Lucerne and Berseem that are largely grown in this country as fodder crops, are self sterile and are largely dependent upon insect pollination to ensure cross pollination and subsequent seed set. Each acre of Lucerne or Alfalfa will contain 200,000,000 to 4000,000,000 individual florets and the enormous job of pollinating each floret becomes manifest. Only the bees with their tireless energy can accomplish this formidable task. The flower structure of these fodder crops is such that only insects with long tongue car pollinate them. It is a well known practice in New Zealand and Australia to keep colonies of bees near the clover fields. Often times the bee keepers are paid for keeping bees in the vicinity of the field. On an average four colonies are sufficient per acre. In some parts of our country the berseem does not set seed and the chief cause for this has been found to be the lack of pollinating insects. In an experiment that was conducted in the Botany Division of the Indian Agricultural Research Institute, it was found out that honey bees formed the chief and important factor governing the setting of seeds.

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SUBJECT No. 6(C).—*Increasing the production of fodder by introducing new fodder crops and improving the existing ones.*

Introduction.—The improvement of livestock in any country has to be brought about by proper breeding and feeding. This note deals with the feeding aspect. It is an admitted fact that the fodder produced in India in the majority of cases is poor in quality and far below the normal requirements in quantity. This quantitative insufficiency and the low nutritive value of the staple fodders are recognized as the chief causes for deterioration of cattle. Most of the cattle of our country are underfed and uncared for and the bulk of them are let loose in the village common or *porombokes* to fend for themselves. The main roughage is the dry straw of paddy, wheat, cholam, ragi, cumbu, tenai, varagu and samai, left over after thrashing the grains which thus forms the by-products in the cultivation of these crops. They are highly deficient in protein and other nutrients. The practice of mising fodder crops and feeding them green is rare and met with only round about towns where they find ready market. In the villages even if green fodder is available, it is generally given to milch cattle. Regular well laid pastures are quite unknown in most of the Provinces. Hence in our country there is urgent need for increasing the production of fodder in all possible ways, and thus help in improving the condition of our great wealth of cattle which is estimated to be over 215 millions in number.

The following suggestions with special reference to Madras Province are offered for increasing the quantity and quality of fodder for feeding our cattle. Table I gives the approximate quantity of fodder produced, the total number of cattle in the Province, the rate of roughage and concentrates available, etc. It will be seen that the total quantity available in Madras is much too little for the present stock.

The present dearth of fodder can to a very large extent be remedied by bringing more area under fodder crops, raising improved varieties of the fodder grown at present, by introducing new forage crops that could be cultivated under more adverse environments and lastly by economic utilization of the available fodder. In recommending a forage crop, several important factors have to be borne in mind. It should be palatable, nutritious and capable of being grown in a short period of time. The cultivation expenses must as far as possible be the minimum and the crop high yielding so as to give a good return. The physiological characters of the crop and their adaptability to the climatic and soil conditions have also to be considered. They should not be injurious to cattle, when fed green or dry. The straw which forms the bulk of the feeds supplies not only the nutrients but also part of the mineral compounds required to keep the animals alive and fit for work. So they should be rich in proteins and mineral contents. Vitamins and carotene which are highly essential for milch cattle and growing animals should also be available. A part of the nutrients and minerals can be supplied in the form of concentrates. But actually the majority of the cattle do not get any concentrates, and have to depend entirely on straw. Hence it is all the more necessary that straw of good quality in sufficient quantity should be produced to feed the livestock.

Potentialities of millets as fodder crops.—Among the graminaceous plants generally grown as fodder crops, millets possess most of the desirable characters. They are comparatively cheap, heavy yielding, drought resistant and drought evading, and capable of growing under varied conditions of soil, climate and elevations. They may be cut and fed as green fodder or converted into hay and straw for later use. They grow very quickly, particularly the panicum millets, and may be used as catch crops. Their adaptability to all types of soils from the heavy black cotton to light sandy, or gravelly soil is rarely met with in other groups. They are less exhausting and require much less attention than other crops. Some species of millets are found in places of high rainfall, and some others in areas of very low rainfall. While certain species are highly drought resistant, certain others can withstand water logged conditions. In nutritive value, they compare very favourably with the other fodders as given in Table II and the straw of most of the millets is considered superior to paddy straw. The following millets will serve as good fodder crops :—

Sorghum (Jowar).—The most important of the fodder crops grown in this Presidency is *cholam*. It is grown purely as fodder crop in parts of Guntur, Kistna, Coimbatore, Salem, Ramnad, Trichinopoly, Tanjore, Madura and Tinnevelly. There are many different varieties suited to different climatic conditions. Sorghum is versatile, quick growing, responds well to manuring and irrigation, and is an excellent fodder, whether fed green or dry as straw or hay. It is also excellent for ensilage. The variety known as *Irungu* grown in Madura, Tinnevelly and parts of Trichinopoly is very palatable and has been introduced into the Punjab from Madras. Another good variety is the *Periamanjal cholam* of Coimbatore which is very popular as a fodder crop almost throughout the Presidency. Both the green fodder and the dry straw of this variety are highly esteemed by the farmers. The green forage is well relished by cattle and the yield is heavy. It can withstand severe drought. Cholam fodder is very good for milch cattle and work animals. In North India during famine years sorghum played an important part in saving the greater portion of work cattle. It is an excellent storage crop and the straw remains in good condition for many years, if properly dried and stocked. Feeding trials have proved that though the straw of wheat and cholam are relished by cattle, except for the fibre content, the nutrients of *jowar* straw are better digested than that of wheat straw, and in general *cholam* straw supplies more energy than the other cereal straw. The nutritive value of

green *cholam* fodder has been found to be fairly high. An average crop yields 15 to 20 tons of green fodder under irrigation. A crop may easily give 6,000 lbs. of dry straw. The high percentage of prussic acid in the immature crop renders it harmful to cattle if fed before flowering. Hence *cholam* should be used as green fodder only after the plant flowers.

The wild sorghums are equally valuable as fodder crops. The most important among this group is the Sudan grass (*S. sudanense*) which is used for pasture forage and hay. It provides complete nutrient to stock, has a protein content of 4.6 per cent and is very popular. This species grows in soils suitable to sorghum, is quick in growth, and under irrigation it gives 4 to 5 cuttings in a year.

Johnson grass (*S. halepense*)—is another wild sorghum which gives heavy yield of succulent fodder. It is perennial and highly drought resistant. But it cannot be recommended for cultivated lands, as it cannot be easily eradicated later when required.

Pearl millet—Cumbu (*Pennisetum typhoides*).—*Cumbu* (Bajra) gives an excellent green fodder which is succulent and very palatable and has a protein content of 11.9 per cent. As it responds to ratooning, it yields two to three cuttings per year and thus gives much more green fodder than cholam. It has given more than 90,000 lb. of green forage in two to three cuttings. This millet is fairly drought resistant, quick growing and comes up even in light gravelly soils. It is grown in cattle breeding tracts famous for Alambadi and Kangayam animals and is fed to growing animals and work cattle. The *Nadam cumbu* of D aram uram is highly tillering and is much valued as a fodder. It is valued in re:s green fodder, as maturity and drying make the straw coarser and less palatable than green fodder.

Ragi (*Eleusine coracana*).—This is essentially a grain crop and is never grown purely for fodder. It is cultivated under dry or irrigated conditions and the green straw left after the ears are cut forms an excellent feed. The straw of this millet is low in fibre content, easily digested and very rich, the nutritive ratio being 1 : 4.5. It is better than the straw of paddy and many of the millets, and if stacked for some months, its fodder value improves considerably. The yield of both grain and straw is heavy under favourable conditions.

Italian Millets—(*Tenali Setaria italica*).—Though *tenai* gives much less straw than *cholam*, *cumbu* or *ragi*, its capacity for rapid growth, high drought resistance and freedom from pests and most of the diseases enhance its value as a fodder crop. The percentage of protein in this also is fairly high. When cut as green fodder, it is very palatable. This is ready for cutting as green fodder in about six weeks after sowing and an average crop grows up to a height of 5 feet and yields 8,000 to 10,000 lb. of green fodder per acre. The dry straw is in great demand, when there is a fodder famine. In the Bellary black soil area, where *rabi jowar* is a gamble, it is a common sight in village to have stacks of Italian millet straw as fodder for cattle.

Kudiravali (*Echinocloa frumentacea*).—The barn yard millet, as it is popularly called, is one of the useful fodder crops and can grow in poor soils and under water-logged conditions. It is one of the quickest growing millets so far known, stools well, and recovers remarkably after grazing. This is successfully grown in many parts of the world. As a fodder crop, during the hot weather it is quite successful in Sind. In United States of America, this is considered as the best late season feed, taking the place of maize in places where the latter could not be grown. This millet is grown extensively for fodder in Queensland. The straw of this is used in Madras and Mysore as cattle feed, but is considered inferior to *ragi* straw. The chemical analysis shows that as green forage, its nutritive value is high and that it contains 15 per cent. dry matter and relatively low percentage of crude fibre. It is richer in non-nitrogenous substance than paddy, wheat or rye straw in about 50 days after sowing it is ready for cutting and gives

10 to 12 tons of very palatable green forage. When grown for grain, it yields 2,000 lb. of dry straw also.

Panivaragu (*Panicum miliaceum*).—Universally accepted as an emergency fodder crop, this grows more quickly than any other millet and matures in a very short period. It yields about 30,000 lb. of green forage and 7,000 lb. of dry straw under irrigated conditions and about half of it when grown dry. It is capable of gathering and utilizing plant foods from a variety of soils, and the fodder contains nearly double the dry matter of that sorghum. It is superior to the great millet in nutritive value and compares very favourably with maize.

Samai (*Panicum miliare*) *and Varagu* (*Paspalum scrobiculatum*).—These can also be known as fodder crops. Paspalum is one of the valuable pasture grasses in the South-east Queensland. In India it is popular in the southern districts and portions of the Ceded Districts. While P. miliare is rather a delicate crop. *Paspalum scrobiculatum*, on the other hand, is perhaps the hardiest among the millets. The latter comes up under water-logged as well as droughty conditions. Its capacity to thrive even in the poorest soils is fully utilized by the farmers. As with the grain, the straw is also a famine reserve.

Improving the existing fodder varieties.—The importance of the production of improved varieties of fodder was recognized very early, and much work has been done at the Millet Breeding Station, Coimbatore, in this direction. The earliest efforts were made through selection and hybridization. From a study of the local varieties and world collections for their suitability as fodder types, certain desirable selections were isolated. In sorghum, the pithy and juicy varieties are differentiated by the colour of the midrib of the leaves, the pithy having white midrib, while in juicy it is dull green. The juicy types are found in the Deccan. The sorghums in other parts of the Presidency are mostly pithy stalked. The pithy is a monogenic dominant to the juicy type. For the selection of strains suitable for fodder purposes, fourteen varieties of *cholam* were studied. In these, the percentage of juice in the stalk at grain ripening stage was found to range from 11 to 20 per cent. in the pithy, and from 30 to 46 per cent. in the juicy types. Most of these had good sucrose content also. The juicy varieties are well relished by cattle, but they are generally poor yielders and have less survival value. So by hybridization, the desirable characters, such as juiciness and sweetness in stalks, were combined with high yield of both grain and straw. The juicy stalked *Tella jonna* types of Bellary are not fit for Kurnool or Coimbatore. So the need for the evolution of strains for the different tracts has been recognized and included in the programme of investigation. Such types have been evolved and are available at the Research Stations at Coimbatore, Anakapalle, Guntur, Hagari and Koilpatti.

The following are the improved fodder strains of sorghum available at the Millet Breeding Station, Coimbatore :—

Co. 10.—This is a juicy stalked mutant from a *Patcha* jonna selection of Kurnool possessing all the desirable qualities of a fodder type. The plants of this strain are pigmented reddish purple and have juicy stalks with high sucrose content. It can be cut for fodder in about 3½ months and gives 30,000 to 50,000 lb. of green fodder. *Co.* 11 is another fodder strain of *Patcha jonna* having a shorter duration and yielding 13,000 to 17,000 lb. of green fodder. These juicy stalked fodder strains Co. 10 and Co. 11 are superior to the pithy stalked *Periamanjal cholam* in juiciness and sweetness of stalk. Co. 10 grows tall and gives a heavy tonnage of fodder, it being 30 per cent. more than that of *Periamanjal.*

The sorghum straw may be reddish purple, blackish purple or brown in colour The straw of reddish purple type is considered better than that of the others. Most of the varieties of sorghum grown in the districts of Salem, South Arcot, Trichinopoly, Madura, Circars and the Ceded Districts have reddish purple sheath, while the majority of the types grown in Tinnevelly and parts of Ramnad. Madura,

North Arcot, Chittoor and Salem have blackish purple sheath. The Periamanjal cholam strain Co. 1 gives high yield of both grain and straw, but the straw is blackish purple in colour and is not relished as well as red straw. As a result of hybridization, promising selections with reddish purple sheath and juicy stalk have been obtained and are being tested for yield.

The straw of Talavirichan sorghum grown in tracts close to the hills is mostly brown in colour and poor in quality. As the cultivators in these areas get plenty of hill grass for their cattle, the straw of this sorghum is used for the thatching or burning as fuel. Crosses made to evolve a juicy stalked Talavirichan were successful and three valuable selections are under yield tests. A juicy mutant in a Talavirichan selection. *Muthyala jonna*, has been found to be promising and this is also being tested for yield.

Kaki junna is one of the important fodder varieties grown in parts of Chittoor, North Arcot, and Salem districts. It is vigorous in growth, but the stalk is pithy. To improve the fodder quality of this variety, it was crossed with the Honey sorgo of America and the progenies are being studied for selection.

Work on the improvement of the straw of irrigated varieties by hybridizing them with suitable juicy types is also in progress.

As a result of intensive study and careful plant breeding it has been possible to evolve improved varieties of fodder in sorghum. The account given above shows clearly that plant breeding forms the best means of improving both the quality and quantity of any fodder crop. The present scarcity of fodder can be overcome to a considerable extent by popularizing these improved varieties of fodders, and also by fully utilizing the possibilities of other millets as fodder crops.

TABLE I.

Total population of cattle.

(a) Oxen	16,354,914
(b) Buffaloes	6,280,325
Total ..	22,644,239

Total quantity of feeds available.

Kind of feed.	Quantity in tons.
Dry roughages	21,645,600
Bhusa of pulses and miscellaneous, green fodder	3,341,700
Natural grass from pastures	7,900,800
Concentrated feeds	1,918,000
	34,806,100

Quantity of fodder available per head of cattle ..	9 lb. per day.
Average quantity of dry roughage required for a healthy animal	13 lb. „
Quantity of concentrates required per day ..	3/4 lb. „
Total quantity of roughage required at this rate of feeding	47·6 million tons.
Total quantity of dry roughage available ..	28·0 „
Deficit ..	19·6 million tons (or) 20 million tons.
Concentrates —Quantity required	2·7 million tons.
Quantity available	1·9 „
Deficit	0·8 or nearly 1 million ton.

(Based on figures given in "Rural Problems in Madras" by S. Y. Krishnaswamy, 1947.)

TABLE II.

Average composition of forages.

	Total dry matter.	Diges-tible protein.	Total diges-tible nutrients.	Nutri-tive ratio.	Calcium.	Phos-phorus.
A. Dry Roughages.						
Grass straw	85·0	1·8	40·0	21·2	..	..
Sorghum fodder (sweet)	89·2	3·6	52·7	13·6	0·49	0·14
Peral millet	87·2	4·2	49·8	10·9	..	..
Hungarian millet (Tenai)	90·0	5·2	51·5	8·9	0·30	0·17
Barn yard millet (Kudiraivali) ..	86·5	5·1	47·3	8·3	..	0·20
Broom corn millet (Panivaragu) ..	90·7	5·3	51·8	8·8	..	0·19
B. Green forage.						
Pasture grass	30·2	3·3	19·6	4·9	0·15	0·04
Sorghum fodder	23·6	1·3	15·5	10·9	0·04	0·38
Peral millet	18·7	1·1	11·9	9·8	..	0·07
Hungarian millet	29·9	1·9	19·1	9·1	0·30	0·12
Barn yard millet	21·7	1·0	14·2	13·2	0·11	0·07
Broom corn millet	24·7	1·2	16·2	12·5	..	0·05
C. Silage.						
Sorghum (sweet)	25·1	0·8	15·1	17·9	0·07	0·04
Sorghum (grain varieties)	31·3	1·1	17·8	15·2	..	..
Millets	31·3	1·6	17·5	9·9	0·31	0·12

Feeds and feeding—Morrison 1936; pages 954—976.

AGRICULTURAL DEPARTMENT, MADRAS,
27th December 1947.

C. VIJAYARAGHAVAN,
Millet Specialist.

APPENDIX VII.

Notes read at the meeting on subject No. 7.

By :—

1. Mr. M. N. Lakshmana Rao
2. Mr. N. D. Gulhati.
3. Dr. P. C. Raheja.

BOARD OF AGRICULTURE AND ANIMAL HUSBANDRY IN INDIA, SOIL AND CROPS WING MEETING, APRIL, 1948.

A NOTE ON SUBJECT No. 7.

Rotation of crops which will give the best results in an irrigation intensity from 35 to 70 acres out of 100 acres.

BY

M. N. Lakshmana Rao, B.A., B.E., Superintending Engineer, Lakkavali Reservoir Works, Mysore State.

Introduction.—A number of irrigation projects are now being taken up all over India, with a view to step up the growing of Food Crops. In order to utilise the stored water under these various schemes to the best advantage, and to spread out the benefits of Irrigation over as large an area as possible, the evolving of a carefully planned system of crop-rotation suitable to the area, and its introduction into the project itself become an important necessity.

Object of crop rotation.—In the tracts where only Sugar-Cane and Paddy have been the ruling crops under Irrigation, both being heavy consumers of water, the extent possible to be irrigated becomes very limited, under any given Irrigation Work. On the other hand, if the cane and paddy crops are rotated with other dry and semi-dry crops the water consumed will be less and the benefit or irrigation can be extended over a much larger area, with the same amount of water. Besides economy in use of water, the Rotation System produces other benefits. The alteration of heavy and light irrigated crops reduces water-logging and consequent soil deterioration. The soil fertility is maintained by the intervening of manurial and regenerative crops between soil exhausting crops. More than all, that dread of Malaria which is inseparably associated with heavy irrigation will have been averted, which is a great advantage.

Before introducing any system of crop-rotation in an irrigation tract, the general procedure is to conduct a thorough soil-survey of the area to demarcate the deep and superior soils from shallow and inferior ones, only the former being suitable for inclusion in the system. This is necessary since the soil is to be suitable for Sugar-Cane, and when Sugar-cane is not grown, for an intensive cultivation of a number of short-term money-crops, to give an equivalent money yield in the same period. It will be uneconomical to apply irrigation water to inferior soils.

The areas thus selected are divided up into blocks or irrigation units which are further subdivided into as many sub-blocks as there are kinds of crops in a cycle of rotation. The crops are alternated in each sub-block according to a planned system of rotation and the water supply from the channel is correspondingly regulated for each sub-block, to suit the particular crop during the rotation.

Requirements for a satisfactory system of crop rotation.—For a successful working of the rotation system under any irrigation work, the following conditions are to be fulfilled.

(1) The water requirements of the crops taken together, at any portion of the year should fairly fit in with the water availability conditions in the Reservoir or in the channel (in case of Anicuts) in that period of the year. For instance, the draw off has to be much less in summer than in the monsoon season. Also the division of the sub-blocks should be such as to admit of easy regulation and control of water while distributing it from the channel branches to the fields.

(2) The crops proposed should as far as possible be such as are already prevalent in the locality, since the ryots seldom take kindly to the crops to the cultivation of which they are not accustomed.

(3) The Division of land into blocks and sub-blocks for purposes of rotation is to be so manipulated as to make it possible for any ryot with a fair amount of holding to get portions of his land under all the 3 or more different crops forming the cycle of rotation in any year, instead of all his lands coming under a single crop in any particular season. The primary needs of a Farmer may be summed up as 3 F's, *i.e.* Food, Fodder and Finance, and unless all three kinds of crops forming the rotation are grown by him each year, his essential needs will not be satisfied.

(4) The rotation of crops may be as far as possible complimentary or supplementary in character *i.e.* deep rooted crops to be alternated with shallow rooted ones, fertilising crops to follow heavy feeders and so on.

Triennial system of rotation under Irwin Canal.—One of the large Irrigation Works in which such a system of crop rotation has already been introduced and is in vogue for over a decade is the Irwin Canal, drawn from Krishnarajasagara in Mysore State. The system adopted is a Triennial Rotation of 3 kinds of crops, Sugar-Cane, Paddy and light irrigated dry crops, so that in any single year 1|3 of the total area comes under paddy synchronising with monsoon period of July to December, 1|3 of the area devoted to money crops like Sugar-Cane, with an intermittent supply of water for 14 to 15 months and the remaining 1|3 left over for cultivation of dry crops with light irrigation.

Certain working difficulties met with in the operation of the Rotation system under the Irwin Canal may be mentioned in this connection.

Firstly it was no easy task to divide the area into blocks of suitable sizes. From the cultivator's point of view the ideal method is to allow each man to divide his holding into 3 parts and put each under a different system of irrigation by rotation. For this, small sub-blocks of 50 acres and less were formed first, but such a course was not found practicable, as it would not fit in with any easy method of control or regulation of water in the channels ; and secondly it was not good for the crop itself since Sugar-cane and dry crops cannot thrive well side by side with paddy. Moreover it was not easy to watch that the entire holding of a cultivator was not put under paddy or cane alone.

On the other hand from the point of view of easy control of distribution of water it would be convenient if all lands irrigated by one branch are put under one kind of crop by rotation, so that the supply could be controlled by operating the Head Sluices. But in such a case when a Head Sluice commands 500 to 1,000 acres, the bringing in of all the area under a single crop, in any one season, necessitates a great hardship on the cultivator. Hence these two extremes had to be reconciled.

The second difficulty was in the fitting in of paddy in rotation with the other crops. Growing of paddy requires the levelling of land into terraces, whereas Sugar-Cane and dry crops thrive better without the terraces. Hence the ryot is put to the extra trouble of forming and unforming the terraces, at every alteration of crop with paddy.

Thirdly, it was seen that as a result of the Ridge Channel's irrigation, most of the low lying areas in almost every block of land became too moist for cane cultivation after a certain period. For want of proper slope even a drainage system could not be laid out, to make them dry enough for cultivation of cane or dry crops. Such areas of land were however suitable for growing paddy year after year and therefore had subsequently to be laid out as permanent paddy blocks.

One notable feature in the Crop Rotation under this channel was the introduction of two new crops *i.e.* Irrigated Cotton of medium staple Co. 4, and "Bangarakaddi" type of drought resisting summer paddy as summer crops under Semi Dry Block.

Rotation system proposed under the Lakkavalli Reservoir, Mysore State.—Several improvements based on the experience gained under the Irwin Canal have been incorporated in this system :—

The procedure proposed to be adopted is as follows :—

The entire area will be soil-surveyed and very heavy soils and very shallow ones, as also alkaline lands will be demarcated and excluded from the system of irrigation. Area alround villages for 1 furlong to 2 furlongs width is set apart for dry or Semi-irrigated crops year after year. Valley points and low lying lands which are difficult of drainage being unsuited for rotation are set apart permanently for paddy. Out of the balance, an extent of about 1|6th the area in selected bits and distributed all over the tract is proposed to be devoted to perennial garden crops, like cocoanuts, plantains and fruit trees.

After excluding all the above types of lands, the remaining area, of good land will be put in under the Rotation System.

Since the area commanded is more than what can be irrigated with the available supply, the cane and paddy areas are proposed to be cut down to only 1|6th of the area each by rotation, so that the intensity of heavy irrigation will work out to about 34 in 100.

Typical crop rotations.—A few typical crop rotations to cover a cycle of 3 years, as contemplated under the Lakkavalli Reservoir Scheme are noted below :—

(1)

						Total
Period in months	18	8	6	4	=	36 months
Crop	Sugar Cane	Manurial and Short term crops.	Paddy	Rest between crops.		

(2)

Period in months	18	5	4	4	5	=	36 months
Crop	Sugar Cane	Potatoes or Cingeli or Maize or Coreander.	Irrigated Ragi	Ground nuts	Rest between crops		

(3)

Period in months	36	=	36 months
Crop	Plantain and Pine apple		

(4)

Period in months	4	12	6	4	4	6	=	36 months
Crops	Potatoes	Lucerne	Vegetables like cabbage, tomatoes	Irrigated Ragi	Ground nut	Rest between crops		

(5)

Period in months	18	6	4	4	4	=	36 months
Crops	Sugar Cane	Vegetables or Garden crops	Irrigated Ragi	Potatoes	Rest between crops.		

CONCLUSION :—

This note emanating from an Irrigation Engineer and not an agriculturist is naturally more in the nature of laying the problem as viewed from experienced before the learned members of this Assembly and it is for you to deal with the subject fully and to make your valuable suggestions towards the solution of the problem.

Item 7.—The rotation of crops which give the best results in an irrigation intensity from 35 to 70 acres out of 100 acres.

Introductory note by N. D. Gulhati, I.S.E., M.I.E. (Ind.), Secretary, Central Board of Irrigation.

At the seventh meeting of the Central Board of Irrigation held in November, 1936, two papers were presented one by Mr. M. R. Richardson, C.I.E., I.S.E., Chief Engineer, Irrigation Branch, U.P. and the other by Mr. J. D. H. Bedford, I.S.E., Chief Engineer and Secretary to Government P.W.D., Punjab. Irrigation Branch, Lahore, on the Subject "Desirable intensity of irrigation indicated by scientific rotation of crops affecting canal design and working". Copies of these papers* are enclosed as an Appendix to this note.

Both the notes were introductory in nature, and were based on the experience gained in the U.P. and in the Punjab. Dr. W. Burns, Technical Advisor to the Imperial Council of Agricultural Research, commenting on the first paper (from U.P.) remarked as follows :—

> "The problem of a scientific rotation is one in which it is difficult to generalise since different provinces and different areas in the same province, require different rotations. A rotation is determined in the first instance by the needs of the soil and a fair amount of data regarding different rotations both under rainfall and under irrigation is available with the provincial departments of agriculture. Further work on these subjects is being done at the chain of sugarcane Research Stations financed by the Council of Agricultural Research. Hence it is essential for the Agricultural Scientist and the Irrigation research worker and engineer to collaborate closely in these questions of rotations and intensity of irrigation.".

At the meeting referred to above general discussion took place on the possibility of introducing any such rotation as might be found suitable and it was agreed that there was very little likelihood of such a rotation or intensity being adopted voluntarily by cultivators, and it was practically impossible to enforce it. (This view was probably based on experience in Northern India). After discussion, the following resolution was passed by the Board :—

> "It is resolved that, while appreciating the benefits likely to be derived by introducing scientific crop rotations, this Board is of the opinion that the question raised of attempting to enforce them must be entirely a Provincial one as it does not lend itself to general application.".

The President of the Board (Mr. M. R. Richardson) at its 1938 meeting, quoted an instance in which the United Provinces Agricultural Department had proposed to investigate the problem of rotations in irrigated areas, but he found that their proposals would involve an intensity of about 125 percent, which was an impossibility under *zamindari* conditions. He said that one thing, the irrigation department wanted information on, was that rotation which would give the best results in an intensity of 35 acres out of 100 acres in the cold weather.

This problem appears to have left for investigation by Agricultural Departments of Provinces but, so far as known to the Board, little appears to have been done in the matter.

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* Originally published in CBI Publication No. 14—Annual Report (Technical) 1935-39 pages 99 and 109.

The Central Board of Irrigation is grateful for the opportunity afforded to discuss the problem in this Meeting* of the Crops and Soil Wing and would request that information on the subject that is available be collected and a programme of further action drawn up with a view to obtain reliable results applicable in different parts of the country.

N. D. GULHATI,
Secretary,
Central Board of Irrigation.

APPENDIX.

Note on "Desirable intensity of irrigation indicated by scientific rotation of crops as affecting canal design and working" by Mr. M. R. Richardson, C.I.E., I.S.E., Chief Engineer, Irrigation, Western Canals, United Provinces.

This note is largely based on United Provinces experience and has been written to provide a basis for discussion of an important subject.

2. By intensity is meant the ratio the area recorded as irrigated in a year bears to the culturable area commanded by a distributary or by an outlet as the case may be.

3. Before seeking to determine the most suitable intensity to allow for it is first necessary to determine the best crop rotation. Unfortunately, so far, it has not been possible to make a rotation, ideally the best from an agricultural point of view, fit in with market demand. For instance, cotton may be ideally suited to agricultural demands but there is little use in growing cotton which markets will not buy at a reasonable price.

The quality of the soil and height of spring level are factors which influence intensity as does the supply of manure, at present unfortunately small, available to the cultivator.

The quality of the cultivator largely determines the actual intensity and is a factor over which irrigation engineers have no control. A tract inhabited by "Jats" gives the irrigation engineer a problem different to that presented by a tract inhabited by "Gujars".

The curse of fragmentation adversely interferes with the rotations used and so the intensities.

The character of the normal rainfall will greatly affect intensities.

Lastly, variations in weather conditions from year to year will greatly alter the size of the area irrigated and make a quantitative analysis of results impossible and a qualitative analysis difficult.

To attain quick returns and limit capital expenditure an irrigation engineer may be tempted to aim at a very high intensity but the engineer, who desires to do the greatest good to the greatest number and to obtain the maximum continuous output from the soil, will limit the intensity by limiting the water supply and in so doing he will get in the long run the best continuous return of revenue.

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* Actually it was in March, 1947, that the Central Board of Irrigation requested the I.A.C.R to include in the agenda of the meeting of number subjects of common interest to Irrigation Engineers and Agricultural Officers, but only one subject—item 7 was included and intimation to this effect was received by the Board only in February, 1948, giving it little time to contribute to the discussion.

4. Bearing these points in mind, the question may now be studied in more detail.

5. The maximum intensity possible is obviously 200 and this is in fact obtainable in the case of outlets irrigating nothing but rose, a very profitable crop which justifies a free use of manure but for which the market is very limited.

If the area in question is a typically rice area, the permissible intensity is 100. The whole area can be under rice and will need and take water in Kharif but will *neither need nor take water in rabi. Water supply in the rice season is ample and* the permissible in this case can also be actual.

6. In areas suitable for the growing of sugar, Agricultural officers state that the best rotation in the absence of abundance of suitable manure is :—

Year	1st		2nd		3rd		4th		5th	
Season Kharif or Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
Crop ..	Sugar	Sugar	Fallow	Wheat	Fodder or Cotton	Gram	Fallow	Fallow	Sugar	Sugar

Normally, gram does not need irrigation and cotton does and, therefore, when cotton can be grown, the best rotation requires an annual irrigation intensity of 75 per cent. and of cropping 100 per cent. and of ' dofasli ' area 25 per cent.

Fodder crops can be sown after the rains have broken and, therefore, in places where cotton does not flourish, the best rotation, strictly speaking, only requires an annual intensity of irrigation of 50 per cent. but if water is available for fodder crops, the annual intensity can be allowed to rise to 75 per cent. without objection always, provided climate, soil and cultivators are worthy of such treatment. In fact, a cultivator will find it impossible to maintain as much as 25 per cent. of his holding under sugar unless he can be sure of providing some cultivated fodder before the break of the rains. Ratooning of Coimbatore sugars sown at the proper time is held now-a-days by officers of the Agricultural Department to be an uneconomic factor in Northern India. If the water supply is suitably limited. ratooning will not be adopted to any very undesirable extent. In this matter the opinion of the Agricultural Department is changing from time to time and will very probably change again.

7. In non-sugar areas a suitable rotation is :—

Year	1st		2nd		3rd	
Season, Kharif or Rabi	Rabi	Kharif,	Rabi	Kharif	Rabi	Kharif
Crop, Kharif or Rabi	Wheat	Cotton	Fallow	Fodder	Gram	Fallow.

In this case the annual intensity of irrigation need not exceed 66 per cent. if the rains are kind and in no case 100 per cent. The cropping intensity is 133 per cent. and the ' dofasli ' percentage is 33.

8. An annual intensity of less than 20 per cent. is of little use as famine protection and the construction of a project providing for an annual intensity of less than 20 per cent. can seldom be justified administratively or financially.

9. In areas where spring level is within 5 feet of the surface, the ideal intensity is nil. When spring level is more than 5 feet and less than 20 feet below the surface, great caution is necessary. Intensities which might be suitable for ordinary circumstances should seldom be allowed.

10. In the United Provinces Manual of Professional Orders—1928 Edition—it is stated that the percentage of the area actually commanded by a channel usually allowed for annual irrigation is 35 to 50 per cent. according to the nature of the soil and that in actual practice from 20 to 30 per cent. in the kharif in villages of the Ganges-Jumna Doab. This statement is definitely incorrect as shown by the figures attached to this note (Statement of figures not included). In the design of the Sarda Canal provision was made for the irrigation in the rabi fasl of from 23 to 30 per cent. of the culturable area actually commanded, the lower percentage being taken for the poorer soils. Experience will probably prove that in some parts, at any rate, a higher intensity can be allowed and as the provision for losses was more than generous and demand comes very much later in the north of the doab than it does in the south and one watering there is usually ample for wheat, there should be no difficulty in working to a higher intensity.

11. When the water supply available is insufficient, as is often the case in the United Provinces, the necessities of good administration may require that water be spread over a larger area than the requirements of the ideal crop rotation indicate as suitable even though thereby the capital cost of a canal system is made larger and the annual returns smaller than justifiable by pure economics.

This examination shows that in areas suited to sugarcane, the area under sugarcane should not be allowed to exceed 25 per cent. of the holding, that the under sugar should equal the area under other kharif and that the total area under sugar and other kharif should equal the area under rabi.

12. A rough examination of actual intensities obtained on the canals of the United Provinces will now be briefly attempted.

The market would be swamped and prices would slump and the crop would become unsaleable if cotton were grown on the scale required for the rotation discussed in paragraphs 6-7. We find, as we ought to expect that the cotton area is much smaller than required for the rotations discussed. In the case of sugar areas an examination of outlet statistics of long established channels shows that prior to the sugar boom in tracts where the water supply was ample the command was irrigated as follows :—

Rabi	39%
Sugar	26%
Other Kharif	13%
Total Annual Irrigation	78%

At the present moment sugar tends more and more to encroach on both other kharif and rabi. The tendency appears to be due to an unhealthy over stimulation of the sugar industry. In the sugar areas cotton does not form a large percentage of the Kharif crop but supplies being ample, cultivators sow fodder crops before the rains. It would appear that Kharif supplies could be diverted to other areas with advantage and, in fact, this has recently been done to the benefit of the Lower Ganges and Agra Canals.

In no case is the area irrigated in rabi excessive. Wheat and its allies form from 16 to 40 per cent. of the total rabi area. The percentage of wheat grown in not a few divisions is greater than is permissible in a scientific crop rotation. For this excess market prices and ignorance are both responsible but it is noteworthy that the more skilled the cultivator the closer the percentage tends to the ideal. On the Lower Ganges and Agra Canals the irrigated rabi area is much less than a good rotation can tolerate. This is due in great part to the water supplies available being insufficient. The irrigated Kharif area is also, and to a more marked extent, below ideal requirements partly due to the shortage of water, but, to a certain extent, on account of the idiosyncrasies of the cultivators of those parts.

13. A table is attached showing the percentages of various kharif and rabi crops according to the rotations discussed and the discharges that would be required were these intensities allowed for.

In the United Provinces, at any rate, water is never available nor are conditions suited for irrigation on the scale required for intensities A and B.

Intensity C is both allowable and obtainable in some places. It would not be advisable financially nor from an engineering point of view to design for an alternate kharif discharge of 7.1 cusecs per thousand acres of command. In the United Provinces the difficulty of providing water for kharif is overcome by running channels for which intensity C is suitable on a more liberal roster than the others.

In the United Provinces water is not available for intensity D and remarks on intensity C are similarly applicable to intensity E which provides the basis of design.

14. This note is perhaps somewhat elementary but experience shows that irrigation engineers are sometimes over-optimistic in their forecasts and apt to ignore the effect of crop rotation and it is hoped the note may help to focus attention on a point of view of importance which does not always receive due attention.

	Kharif						Rabi					
	Sugar.	Cotton.	Other Kharif.	Wet.	Dry.	Total.	Sugar.	Cotton.	Other Rabi	Wet	Dry	Total.
A. ..	25	25	.	50	.	50	25	25	25	75	..	75
B. . ..	25	..	25	50	.	50	25	25	25	75	..	75
C. ..	25	.	25	15	25	50	25	25	25	50	25	75
D. .. .	..	33	33	66	.	66		33	33	66	..	66
E. .. .	..	33	33	33	33	66	..	33	33	33	33	66

A. of 1,000 acres, Rabi plus Sugar will be 750, alternate, duty 120, discharge 6·25; kharif 500 duty 70, discharge 7·1.

B. of 1,000 acres, Rabi plus Sugar will be 750, alternate, duty 120, discharge 6·25; kharif 500, duty 70, discharge 7·1.

C. of 1,000 acres, Rabi plus Sugar will be 500, alternate, duty 120, discharge 5·50; kharif 660, duty 80, discharge 8·25.

E. of 1,000 acres, Rabi will be 330, alternate, duty 120, discharge 2·75; kharif 330 duty 80, discharge 4·12.

D. and E. require 60 days running before the break of the rains.

Note on "Desirable intensity of irrigation indicated by scientific rotation of crops as affecting canal design and working", by Mr. J. D. H. Bedford, I.S.E., Chief Engineer and Secretary to Government, P.W.D., Punjab Irrigation Branch, Lahore.

I would like to suggest another angle of approach to the subject. Consider the average holding of the cultivator and the unit of area proposed to be allotted to Crown Waste tenants. A zamindari family requires a minimum acreage of crop to be self supporting : knowing the average holding and the acreage of crop required, we have a reliable guide to the minimum intensity of cultivation required to make a canal prosperous. This is important in Crown Waste areas ; as a converse, the smaller the intensity of cultivation, the greater the Crown Waste area that must be given out as a unit to support a cultivator. Agricultural land has little value unless it produces crops, hence the price of such land varies with the intensity of cultivation. All transactions, from the building of the canal to the cultivation of each small holding is largely governed by financial considerations and very cogent reasons are necessary to justify the deliberate depressing of land values by artificial reductions in intensities.

In what has been said above the term "intensity of cultivation" and not intensity of irrigation has been used. The zamindar is primarily concerned with the area of crops that he can mature each year. It is of subsidiary importance to him whether the area is matured in rain or canal water. Hence it appears impossible to lay down an optimum percentage of irrigation of general applicability. Rain, snow, and canal irrigated crops may be said to be complementary to each other. Where rainfall is so favourable that many crops can be sown and matured in rain the percentage intensity of irrigation may be moderate. We have two examples of such areas in the Punjab of Western Jumna and Sirhind Canals, but where rainfall is insufficient to grow any crops, the intensity of irrigation must be high as on the Lower Chenab Canal. The point being that on all these 3 canals the intensity of cultivation on the culturable area remains the same. It has been argued that because the percentages of irrigation on the Sirhind and Western Jumna Canals are 40 to 50 per cent., therefore, the Pakpattan canal would flourish on 57 per cent. intensity of irrigation. It has not flourished and prices of land are very depressed, because the rainfall on the Pakpattan area is insufficient to grow any class of crop while the rainfall on the Western Jumna and Sirhind is sufficient for many crops and the percentage of cultivation on these latter canals is in fact much higher than on the Pakpattan.

The Punjab and India generally is a land of small holdings, and in the Punjab wherever rain and canal water is favourable the whole cultivable area is sown each year, and even in areas where this has been going on for the best part of a century no deterioration has resulted : the cultivated area tends to rise.

While it is probable that there is no such thing as an optimum of irrigation of general applicability there may be an optimum percentage of cultivation, but in this land of small holdings such percentage is likely to be near 100 per cent. It seems, therefore, that one line of approaching the subject is to accept the facts and to see how best the Agricultural Department and ourselves can graft on it a suitable system of rotation of crops.

In the Punjab we have not got a purely rice canal nor is there any canal where sugarcane is the principal crop. Gram is a crop usually grown on light sandy loams which are unsuitable for Cotton and Sugarcane, and it is doubtful whether Gram and Sugarcane can be rotated.

The proposed rotation of Sugar, Wheat, Cotton and Gram suggests similar percentage of cultivation for such crops. In the Punjab the percentages are as given below :—

Wheat	25 per cent. to 35 per cent.
Cotton	20 per cent. to 25 per cent.
Sugarcane	1 per cent. to 7 per cent.
Gram	5 per cent. to 15 per cent.

In the United Provinces it seems that of recent years Sugarcane has become the principal irrigated crop, but this is not so in the Punjab where the rainfall is small, the air less humid, and where irrigation water is not available for large areas of sugar ; Sugarcane also has not the same sucrose content as in the United Provinces hence the best scheme of rotation of crops in the United Provinces may not be the most suitable in the Punjab.

Where the spring level is within 5 ft. of the surface, canals are never projected in the Punjab, but it does happen in some restricted areas that in course of time the subsoil water rises to within 5 ft. of the surface. In such cases it is impossible generally to cut off irrigation or even to curtail it drastically. If there are salts in the soil they will rise to the surface and will tend to throw the area out of cultivation and the only way to save that area is to wash the salts away and cultivate it regularly. If such an area has no salts, it is still necessary to supply canal water to allow the seedlings to take hold, while the subsoil water may be high enough to supply moisture to a grown crop it is generally insufficient to allow of a crop germinating. It is not a practical proposition to destroy the livelihood of cultivators in such areas without compensation.

With a general water table the subsoil water in any such areas is not as a rule controlled by the water put in the soil in that area, but by the general subsoil water movements in the tract as a whole, and the cutting off of irrigation in restricted areas, at least in the Punjab, does not affect the water table, but ruins the land and the cultivators. It is, therefore, not possible to lay down any hard and fast rules governing the conditions under which canal water shall be given to any area. Each area must be considered on its own merits and no general conclusions can be drawn as to relative urgency of a water supply to competing areas on the data of subsoil water levels. It is to be remembered that a percentage of irrigation gives no clue to the canal water being supplied to the land because there is a big difference in the quantity of water required to mature different crops.

In the Punjab no attempt is made to control the areas of a crop, but such of these vary in accordance with two factors.

(1) Price of out-turn.

(2) Supply of water available at the sowing period tempered by experience of water likely to be available for maturing. The area of a crop varies from year to year with the water supply and varies over a period of years with the rise and fall of money value of the crop produce.

Hence at least in the Punjab for successful colonization the percentage of irrigation depends on the area of crop that can be grown on rainfall. Rice and sugarcane are not principal crops. The land is held on small holdings where a very big percentage of cultivation is necessary for contentment and the Agricultural and Canal Departments unite together to graft in a system of cultivation a rotation of crop most suitable to it.

For the use of members only.

I.C.A.R., C. & S. Wing Meeting, April 1948.

SUBJECT No. VII.—*The Rotation of Crops which will give the best results in an Irrigated Intensity from* 35 *to* 70 *acres out of* 100 *acres.*

A REVIEW

BY

P. C. Raheja, Agronomist, Indian Agricultural Research Institute, New Delhi.

General.—In canal irrigation the critical factor is the amount of Water available for growing crops. The character of irrigation supply is also an important factor which determines the (1) types of crops and (2) area to be cropped with different crops such as area under food, feed, fodder, horticultural and cash crops. With adequate summer and winter supply the proportion of area under *Kharif* and *Rabi* crops remains equal under arid conditions. Where, however, irrigation is available as a protective measure against drought, cash crops occupy a larger proportion of the area than is otherwise possible. Under irrigated conditions proper rotation of crops ensures financial stability of the farmer and productive stability of the land.

In the Punjab out of a total irrigated area of 17,603 lakhs acres, *Kharif* and *rabi* areas respectively was 7,265 and 10,340 lakh acres, of this total the area irrigated by Government canal is 12.5 million acres. This forms 70 per cent. of the gross irrigated area. Out of the remaining irrigated areas 26 per cent. is controlled by wells and 3 and 1 per cent. by private canals and other sources of irrigation. Roberts and Sing (9 by comparing the cropping on Lower Bari Doab, Lower Chenab, Lower Jhelum and Pakpattan canals have shown that even under perennial irrigation the cropping varies a good deal. From the comparison they have concluded that the portion of crops in the cropping in any canal commended area varies with the proportion of irrigation supply available in summer and winter. It of course also depends upon the texture of the land. The principal grain and cash crops are wheat and cotton. The irrigated intensity on all these canals ranged about 70 per cent, of which wheat occupied 33, cotton 25.6, *toria* 2.75, sugar cane 1.25 gram 2.7 and maize 2.9 per cent. of the area. The area under maize and sugarcane was limited, because of larger water requirement of these crops. Larger area under cotton also limited the increase under maize and sugarcane. The various rotations followed have been listed by them as under :—

1. Wheat, *Toria*, Cotton—Three crops in three years.
2. Wheat, *toria*, Cotton—Four crops in four years.
3. Wheat, maize, *Senji*, Cotton—Four crops in three years.
4. Maize, *Senji*, cotton—Three crops in two years.
5. Wheat, maize, *senji*, sugar cane—Four crops in three years.
6. Chari + Guara, gram, cotton—Three crops in two years.
7. Wheat, cotton—Two crops in two years.
8. Gram, Wheat—Two crops in two years.

Except in rotations 4 and 6 in all other rotations wheat occupies a definite place. These two rotations are less common. It is common knowledge that one rotation cannot cover the whole farm. Small supply of manure usually limits the

area under maize and sugar cane. Cotton seldom follows wheat. It occupies area after fallow, *senji* gram or *toria*. When it follows the last crop farm yard manure is applied to the crop. The whole system in the main is adopted to suit the water supply from the canal. The local climate and the relative profitableness of the various crops have a secondary influence only. No farm can be effectively managed on a one-cultivated-crop basis and yet the cropping by way of rotation is largely determined by the effect various crops have on the production of wheat crop in the Government canal areas.

In Madras Presidency about 7.7 million acres in 1941-42 were under irrigation, which formed 21.18 per cent. of the net area sown. In various tracts of the Presidency different systems of cropping are practised depending upon the type of soil and the nature of rainfall. In drier areas the principal crops are millets, sorghum, and cotton (5). In wetter areas paddy occupies a prominent position. The rotations for the dry land areas altogether differ from those of wet or garden lands. Canal irrigation is in Vogue in Sarda river tract, Godavari deltas, Kistna delta, Cuvery-Mettur project area, Periver Valley project system, Tambra parni valley irrigation supply area and west coast inundation system (5 and 8). The intensity of the irrigated area to the total is nowhere less than 100 per cent. The rotations with rice and *ragi* in the different tracts are as under :—

A. *Ganjam Irrigated tracts*—

1. *Ragi*, *Sann hemp*, rice—Three crops in one year (or *Gogu* for fibre).
2. *Ragi*, Rice, Green gram or black gram—Three crops in one year. (Sown in standing crop of rice).
3. Rice, Gingelly, Rice—Two crops in two years.

B. *Vizagapatam Irrigated tract*—

1. *Ragi*, rice, Gingelly—Three crops in one year.
2. Cumbu or maize or jute, Rice, *Ragi* Gingelly or onions—Four crops in two years.
3. *Ragi*, Rice, Gingelly and Indigo—Three crops in one year. (Indigo is either green manured or used for dye production).
4. Sugar cane, Rice, Rice—Three crops in three years.
5. Rice, Vegetables—Two crops in one year. The area suited to No. 4, and 5 rotations is limited.

C. *Western, Central and Eastern deltas of Godavari*—

1. Rice, Sann hemp, Fallow—Two crops in one year or Gingelly.
2. Rice, Sann hemp, Sugar cane—Three crops in two years, sugar cane is important crop in the Eastern delta only.

D. *Eastern and Western Deltas of Kistna river*—

1. Rice, 1 Sann hemp (Fodder)—Fallow—Two crops in one year. 1 Black gram or Green gram (Grain).

E. *Chingleput, South and North Arcot Districts*—

1. Rice follows Rice on heavy lands—One crop a year.
2. Cotton or *Cholam* or tobacco or Cumbu, Rice, *Ragi* or Gingelly—Three crops in two years.
3. Sugar cane, Rice, Rice—Three crops in three years.

F. *Cuvery-Mettur project tract*—

1. Rice, Fallow—One crop a year.
2. Rice, Green or black gram + Indigo mixed—Two crops in one year.
3. Plantain or Sugar Cane, Rice, Rice—Five crops in five years. (Three years).

G. *Periyer Valley*—

1. Rice, Fallow—One crop in a year.
2. Rice, Green or black gram—Two crops in a year.

H. *Tambraparni Valley*—

1. Rice, ½ Black or Green gram—Two crops a year.
   ½ Gingelly.
2. Rice, Field beans, Cholam—Three crops in two years.

I. *West Coast.*—The water supply in South Kanara is more copious than in Malabar. The rotation practised is as under :—

Rice, ½ Green or Black gram—Two crops in one year.
½ Gingelly.

From the above it will be observed that most of the irrigated area rotations in Madras Presidency contain rice as one of the crops.

In Bombay Presidency irrigation is practised to a limited extent in the Deccan Canal tracts. The rotations followed are :—

1. Bajari, Potatoes—Two crops in one year.
2. Bajari, Chillies—Two crops in a year.
3. Bajari, Groundnut—Two crops in a year.
4. Sugar cane, Sugar cane, Sugar cane, Bajari, Sann hemp (Plant Crop) (Ratoon) (Ratoon)—Five crops in four years.
5. Bajari, Tobacco—Two crops in one year.

The last rotation is practised on Bhatta soils (6).

In Central Provinces and Berar 610,000 acres are under irrigation. The irrigated crops are cotton and rice. Some of the important rotation practices are :—

1. Millets, cotton, groundnut, cotton—Four crops in two years.
2. Pulses, Cotton, Cotton—Three crops in two years.
3. Tobacco, ½ Bajra, Groundnut—Three crops in two years.
   ½ Pulses.
4. Cotton, ½ Bajra and ½ Pulses—Wheat—Three crops in two years.
5. Rice, Gram, Rice—Three crops in two years.

The first four rotations are followed on high lands. The last one is the most common rotation on lowlands where water supply available more abundant. The irrigated intensity in all cases, therefore, exceeds 100 per cent.

The irrigated area of the crops in Bihar exceeds 718,000 acres. Most of it exists in South Bihar where soils have clayey texture. The irrigated crops are

wheat, cotton, sugar cane and rice. In North Bihar protective irrigation is provided for rice only. The rotations commonly practised are as under :—

Low land areas.

1. Paddy, Mung, Jowar—Three crops in two years.
2. Paddy, Fallow, Jowar—Two crops in two years.

Medium low lands.

3. Jute, Khesari—Two crops in one year.
4. Jute, Peas—Two crops in one year.
5. Paddy, ½ Peas + ½ Khesari—Two crops in one year.

High lands.

6. Paddy, Wheat, Maize, Gram—Four crops in two years.
7. Maize, ½ Barley + ½ Peas—Two crops in one year.
8. Maize, Fallow, *Arhar*—Two crops in two years.

5. Evidently rotations followed on irrigated lands have included in them crops more than one in a year. The intensity in no case is less than 100 per cent. of the commanded area. The rainfall of North Bihar tract exceeds 40 inches and that of South Bihar ranges between 30 and 40 inches per annum. The North Bihar soils being highly retentive of soil moisture the crops in the non-monsoon period do not require irrigation in the *Rabi* season.

The total irrigated area in Bengal is about 245,000 acres which is 0.8 per cent. of the cultivated area in the Province. Irrigation is supplied to sugar cane, vegetables and sometimes, to winter paddy. The rotations (10) adopted are :—

1. Aus paddy, Potato, Sugarcane (Plant), Sugar cane (Ratoon), Arhar—Five crops in four years.
2. Aus paddy, Gram, Sugarcane (Plant), Sugarcane (Ratoon), cucumber—Five crops in four years.
3. Jute, Potato, Turmeric, Gram—Four crops in two years.
4. Aus paddy, fallow, sugarcane, sugarcane (Ratoon)—Three crops in one year.

All these rotations have cropping intensity of over 100 per cent. Pulse crops included in the rotations do not receive any irrigation.

In the United Provinces about 17 per cent. of the area is supplied with irrigation facilities. The extent of irrigated area exceeds 6 million acres. Out of this 4.5 million acres are commanded by canals. The irrigated crops are rice, wheat, sugarcane, cotton, maize and *Jowar*. In most cases irrigation supplements the rains received during the monsoon and the winter seasons. The rotations of crops followed are :—

1. Sann hemp, wheat, cotton, peas—Four crops in two years.
2. Fallow, sugarcane, fallow, wheat—Two crops in two years.
3. Maize, gram or peas—fallow, wheat—Three crops in two years.
4. Maize, linseed, groundnut, wheat—Four crops in two years.
5. Groundnut, sugarcane, sugarcane (Ratoon), fallow, wheat—Four crops in three years.
6. Paddy, ½ Fallow + ½ Gram or Peas — Rice —Three crops in two years.
7. Maize, Peas, Cotton, Berseem—Four crops in two years.
8. Maize, Potatoes, Tobacco—Three crops in two years.

It is evident that on irrigated lands the cropping intensity ranges between 100 and 200 per cent. of the commanded area. Rice lands are usually low lands. They bear two crops in a year. The winter crop not unoften is a pulse crop so that their fertility is kept maintained. On high lands sugar cane, maize and wheat receive irrigation. In Furrukhabad potatoes and tobacco also find a place along with maize on a limited area. All these crops require irrigation for their successful cultivation.

In America experiments on the rotation of crops under irrigation conditions, without any regards of the irrigated intensity of cropping have been reported from Huntley Field Station Montana, Belle Fourche Field Station, Newell, South Dakota, and Scots Bluff Field Station, Mitchell, Nebraska (2, 3, and 4). The crops under study were sugar beets, potatoes, oats, wheat, corn, flax, field beans and alfalfa. The chief objective was to determine the rotations and cropping methods best suited to maintaining and improving land productivity under irrigated conditions. In all 42 different cropping systems were put under test. Continuously (manured and unmanured) cropped series were compared against 2 years, 3 years, 4 years and 6 years rotations. The last two rotations had alfalfa and sweat clover included in them. Twentyfour years records have led the workers to conclude as under :—

1. The high net returns were obtained from rotations featuring sugar beets and potatoes ;
2. Application of farm yard manure increased the value of net returns ;
3. In alfalfa rotations sugar beet yields were higher than without it ; and
4. All continuously cropped plots and all the untreated simple rotations were unprofitable.

Chen and Arny (1) have reported similar results from the Agricultural Experiment Station, Minnesota. McKanzie Taylor (11) has shown that in Egypt with a change over from basin to perennial irrigation a great change in cropping has been brought about. Instead of *rabi* crops alone under perennial irrigation *Kharif* crops such as Maize and cotton, besides a larger area under berseem, follow the *rabi* crops of wheat, berseem and beans. Comparing the place of legumes in the Punjab as against Egypt Roberts and Kartar Singh (9) have shown that in the canal colonies of the Punjab only 11 per cent. of the cropped area is put under the legumes. In Egypt 28 per cent. of the total cropped area is occupied by the legumes. This difference as McKanzie Taylor (5) pointed out, contributes to high yield of Maize and cotton crops in Egypt. Besides, about 160 per cent. average intensity of cropping is attained there as compared to 70 per cent. in the canal irrigated areas of the Punjab.

Conclusions.

From the above review of the rotations of crops and the irrigated intensity of cropping in the different provinces it is evident that except in the Punjab nowhere else the irrigated cropping intensity is less than 100 per cent. In the Punjab in the old canal colonies the cultivator aims at one crop a year. He is not satisfied with less than that. In the new canal system, Sutlej Valley Project, operating in Bikaner State and Ferozepur district the intensity of cropping, attained is less than 35 per cent. The main crops grown are *jowar* and wheat or barley. Very little area is put under the legumes as major portion of the area (over 60 per cent.) remains fallow. This seldom owing to scarcity of fodder, can be kept cultivated and is subject to wind erosion. It is under such conditions that experimental work on rotations of crops from the point of view of the maintenance of soil fertility, conservation of soil and better utilization of irrigation

supplies is urgently called for. In other irrigated areas experimental work on rotations should be systematised and economics or rotations now in vogue and the new ones proposed may be worked out. This long range work may be taken up at some of the Research Station where facilities for such work can be made available.

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